

N85-29541

**Space Station
Crew Safety Alternatives Study**

SSD84-0106

Third Quarter Status Briefing

CONTRACT NAS1-17242

27 FEBRUARY 1984

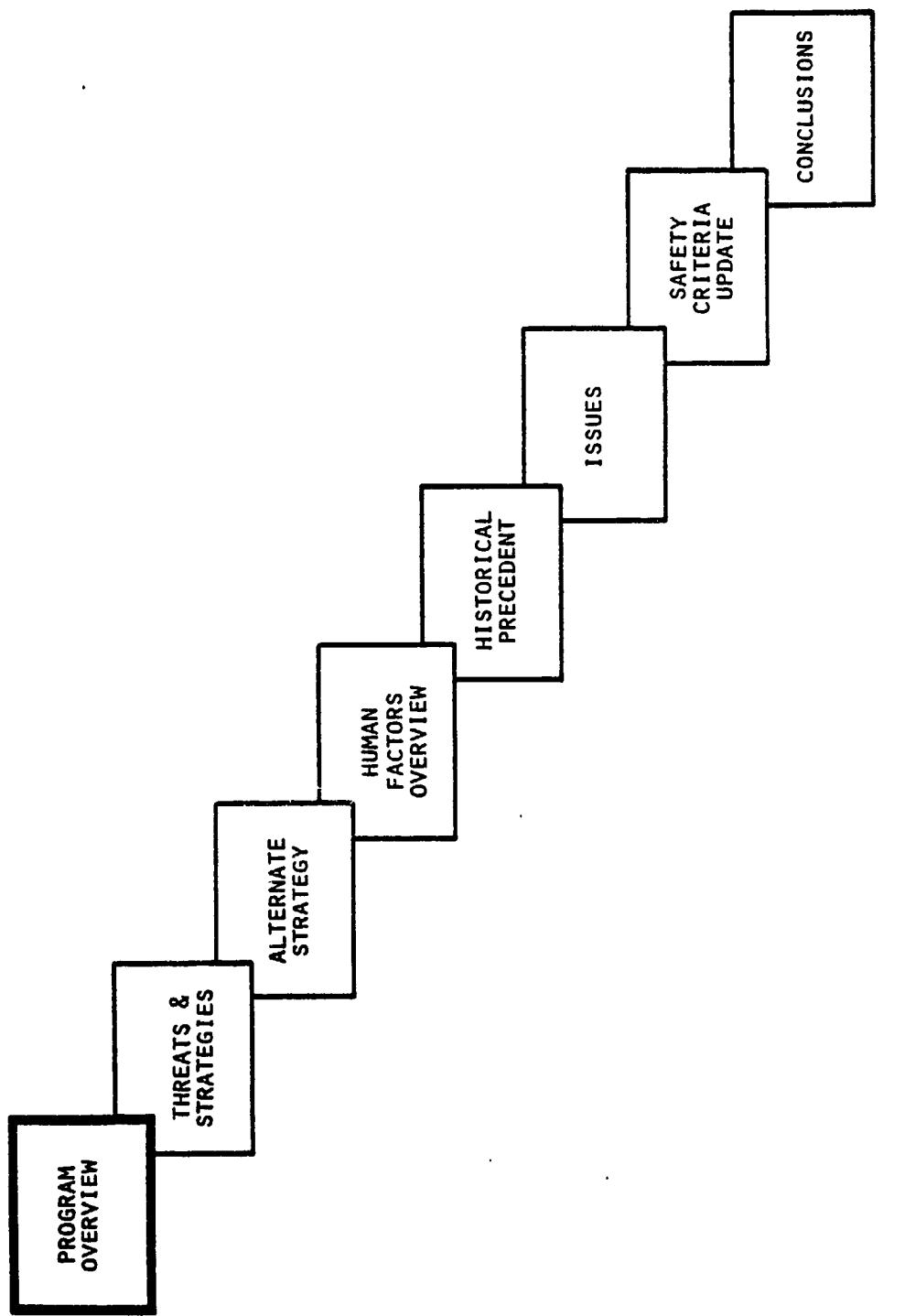
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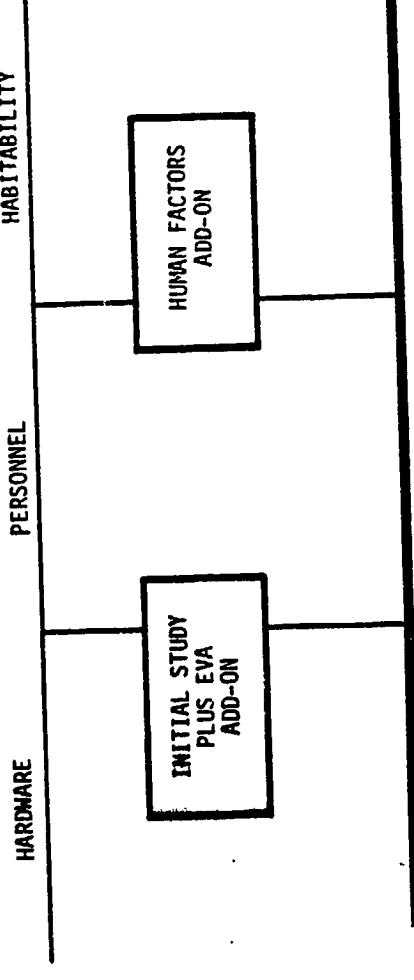
PURPOSE OF STUDY

- IDENTIFY THREATS THAT COULD CAUSE AN ESCAPE OR RESCUE DECISION
- LOOK AT STRATEGIES WITHIN THE BASELINE TO ACCOMMODATE THESE THREATS - GENERATE CRITERIA
- IDENTIFY OPTIONS & PERFORM ROM COSTING FOR ESCAPE/RESCUE
- MAKE RECOMMENDATIONS FOR ADDITIONAL STUDY
 - SOFT AREAS
 - VOIDS

CREW SAFETY STUDY

NAS1-17242

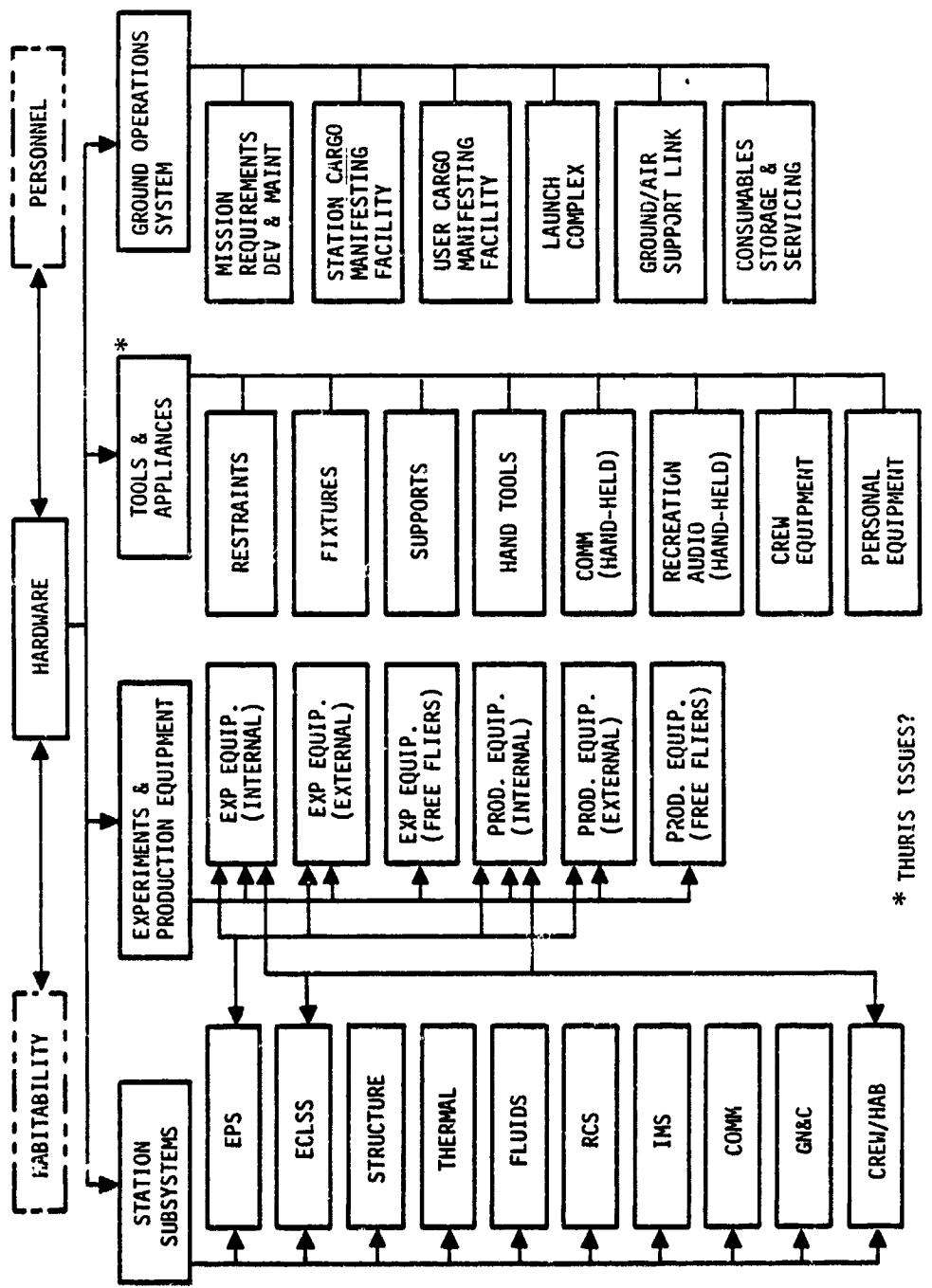
• AREAS ADDRESSED OR BEING ADDRESSED



• OBJECTIVE:

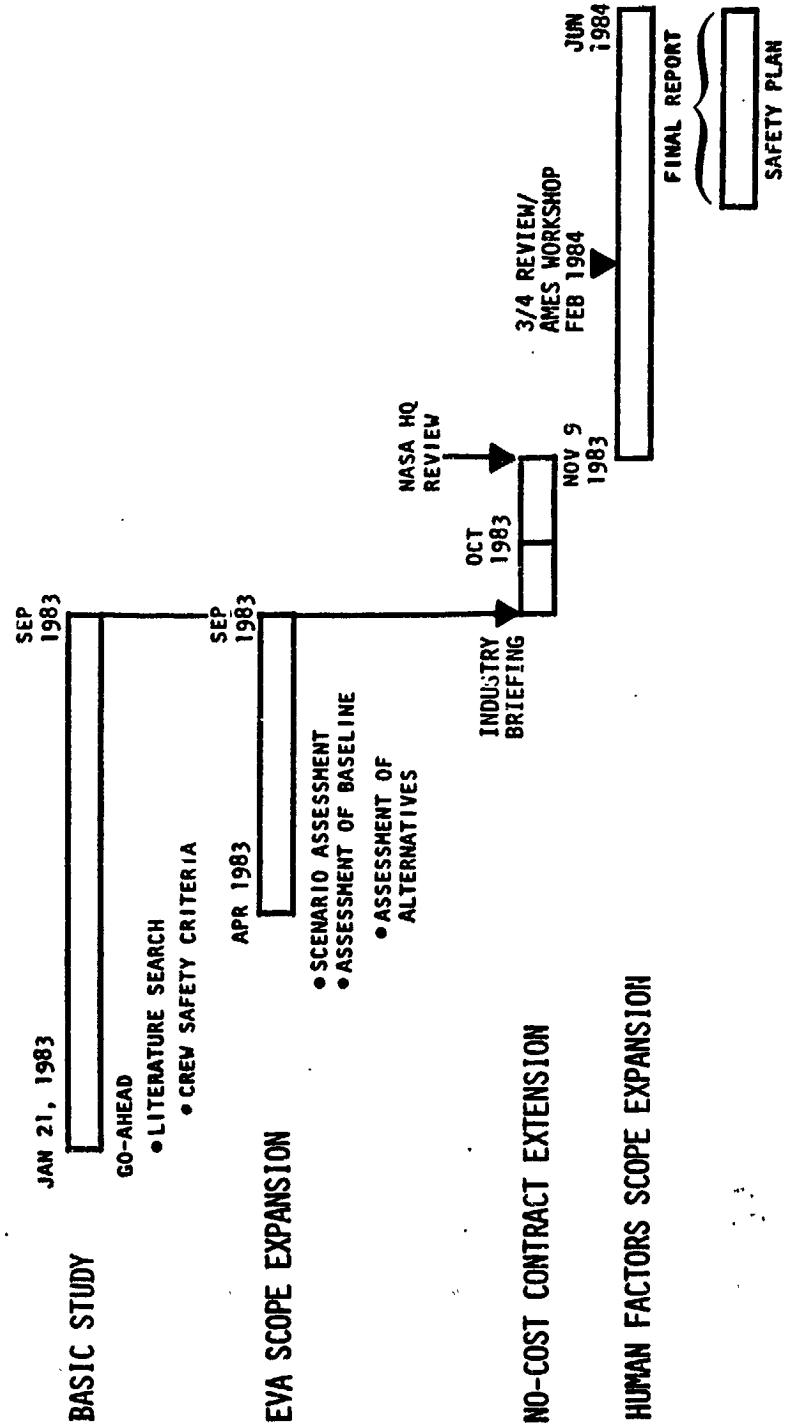
- IDENTIFY SAFETY ISSUES
- PROPOSE CONTROLLING CRITERIA

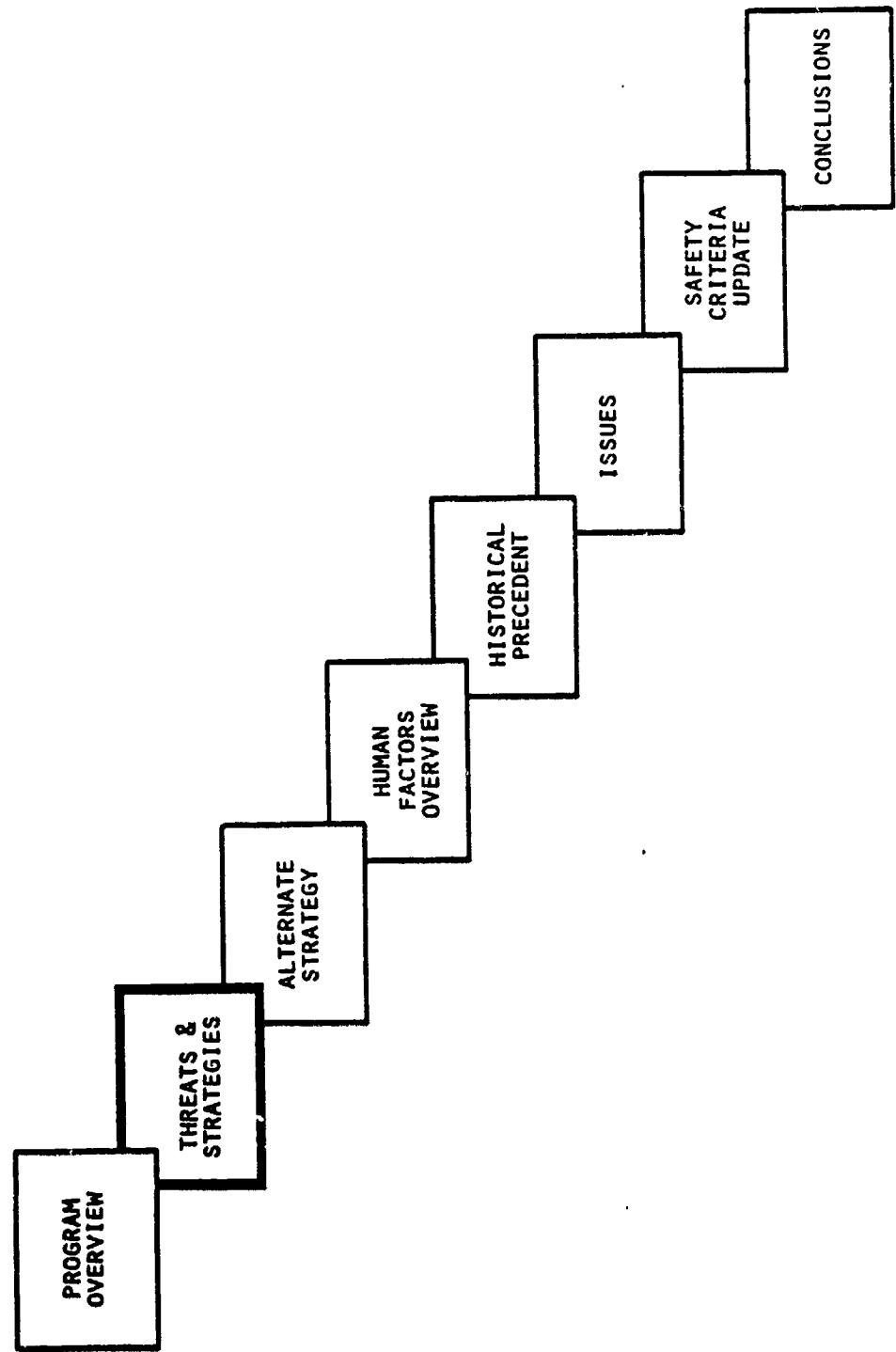
STUDY SEGMENTS - HARDWARE



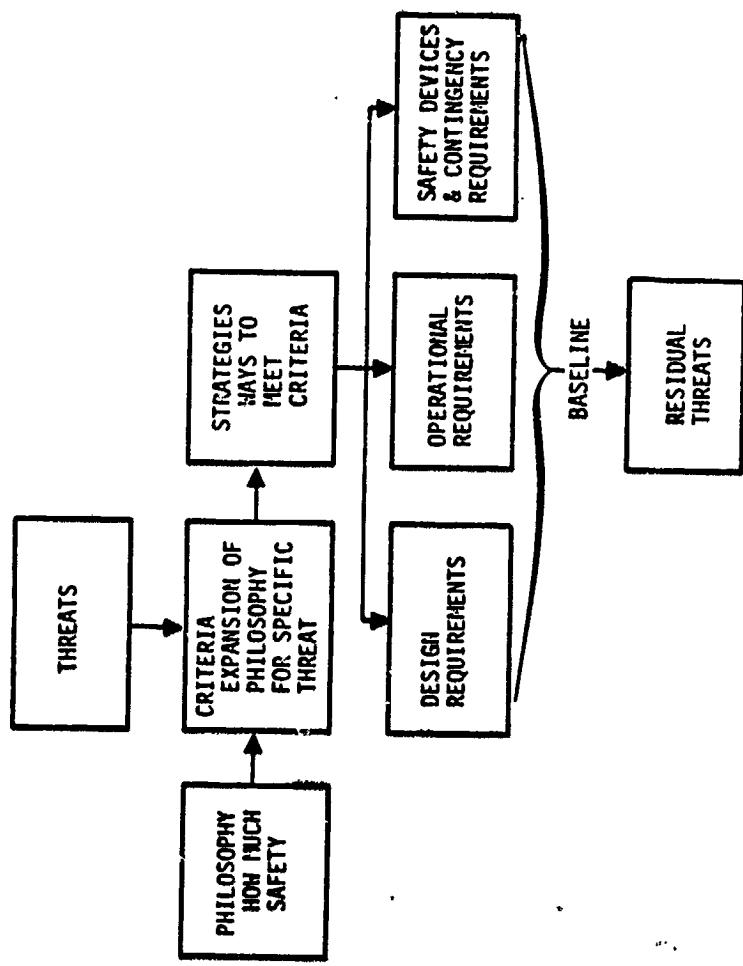
* THURSDAY ISSUES?

SCHEDULE SUMMARY





STUDY APPROACH



SPACE STATION CREW SAFETY
THREAT LIST

- ✓ • FIRE
- ✓ • LEAKAGE
- ✓ • TUMBLING/LOSS OF CONTROL
- ✓ • BIOLOGICAL OR TOXIC CONTAMINATION
- ✓ • INJURY/ILLNESS
- ✓ • GRAZING/COLLISION
- ✓ • CORROSION
- ✓ • MECHANICAL DAMAGE
- ✓ • EXPLOSION/IMPLOSION
- ✓ • LOSS OF PRESSURIZATION
- ✓ • RADIATION
- ✓ • OUT-OF-CONTROL EVA ASTROAUT
- ✓ • INADVERTENT OPERATIONS
- ✓ • LACK OF CREW COORDINATION
- ✓ • ABANDONMENT OF SPACE STATION
- ✓ • METEOROID PENETRATION
- ✓ • STORES/CONSUMABLES DEPLETION
- ✓ • STRUCTURAL EROSION
- ✓ • ORBIT DECAY
- ✓ • LOSS OF ACCESS TO A HATCH
- ✓ • TEMPERATURE EXTREMES
- ✓ • DEBRIS
- ✓ • FREE ORBIT (EVA ASTROAUT)

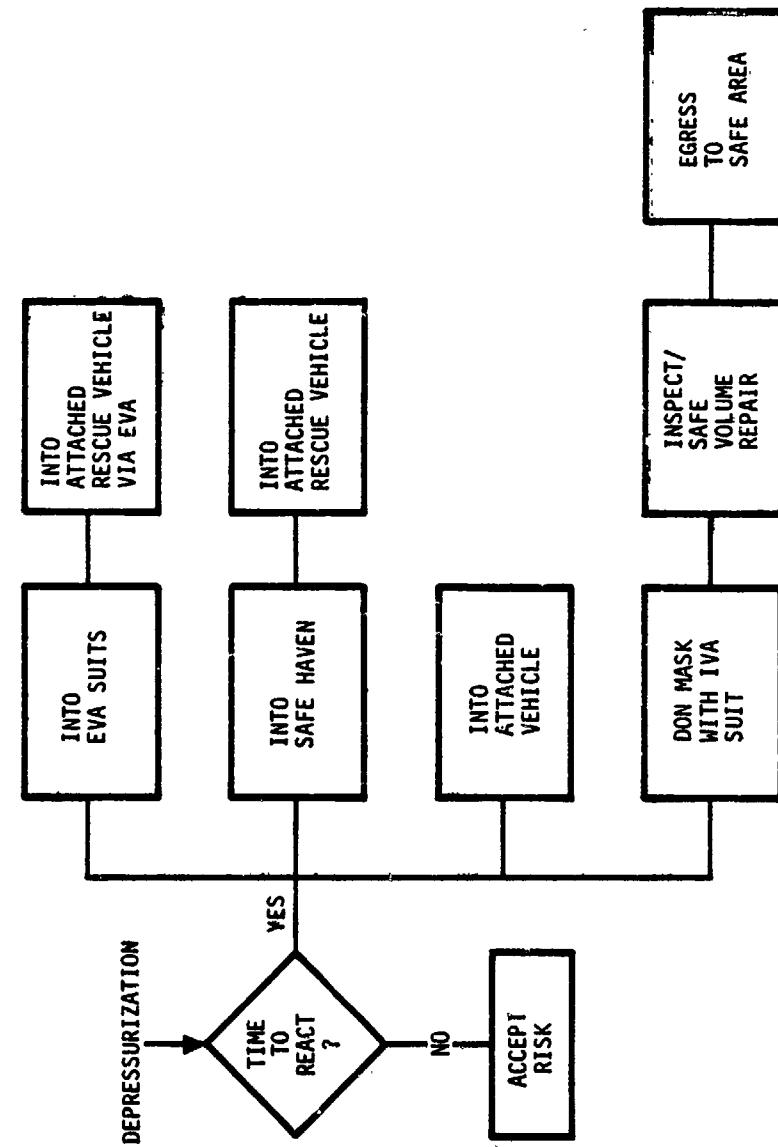
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SPACE STATION SAFETY PHILOSOPHY PRECEDENCE
(HOW MUCH SAFETY?)

CURRENT OPTIONS	COMMENTS
<ul style="list-style-type: none"> • CAUSE NO DAMAGE WHATSOEVER TO SPACE STATION AND NO INJURY TO CREW • CAUSE NO DAMAGE TO SPACE STATION BEYOND ROUTINE MAINTENANCE CAPABILITY 	<p>DESIRABLE: COST TRADE</p> <p>COST TRADE</p>
<ul style="list-style-type: none"> • CAUSE NO DAMAGE TO SPACE STATION OR INJURY TO CREW WHICH WILL RESULT IN A SUSPENSION OF OPERATIONS 	<p>BASELINE PHILOSOPHY</p>
<ul style="list-style-type: none"> • SPACE STATION REPAIRABLE AND OPERATIONAL WITHIN A SPECIFIED PERIOD OF TIME • CREW SURVIVAL AT EXPENSE OF THE SPACE STATION 	<p>MAY REQUIRE ESCAPE/RESCUE</p> <p>IMPLIES EVACUATION AND RESCUE. AS A MINIMUM</p>

THREAT	CAUSATIVE FACTORS	STRATEGY(IES)
DEPRESSURIZATION	<u>UNPLANNED</u> <ul style="list-style-type: none"> • PUNCTURE FROM DEBRIS • INADVERTENT CREW ACTION • INTERNAL/EXTERNAL LEAKAGE 	<p>1. CAPABILITY TO INSPECT/REPAIR INSIDE OF PRESSURE VESSEL</p> <p>2. STATION MINIMUM SURVIVAL FUNCTIONS (MANDATORY OPERATIONS AT ALL TIMES) SHOULD BE COLDPLATED</p> <p>3. HARDWARE FOR OTHER CRITICAL FUNCTIONS SHOULD BE CAPABLE OF BEING TURNED OFF</p> <p>4. NEED TO KNOW LOCATION OF ALL PERSONNEL IN ALL MODULES</p> <p>5. DISCRETE DEFINITION OF "TIME-TO-SURVIVE" NEEDED</p> <ul style="list-style-type: none"> • CONTAMINATION/TOXICITY • EXPLOSIVE DECOMPRESSION • INTERIM SURVIVAL DEVICES <p>6. INFLATABLE PRESSURE BULKHEAD</p> <p>7. PROVIDE SUBSYSTEM DESIGNERS WITH "MAXIMUM HOLE" TO SIZE LIFE SUPPORT SYSTEM WITH NUMBER OF CYCLES (PRESS/DEPRESS) STATED</p>
	<u>PLANNED</u> <ul style="list-style-type: none"> • REMOVE CONTAMINATION • FIRE CONTROL - ALTERNATE • MAINTENANCE DEPRESSURIZATION 	<p>1. STATION SHOULD BE CAPABLE OF TBD PRESSURE VOLUME CHANGEOUTS (3 MINIMUM)</p>

DEPRESSURIZATION ESCAPE/RESCUE OPTIONS



EFFECTS OF A FIRE IN A MODULE IN SPACE

- REMOVAL OF OXYGEN FROM MODULE
- PYROLYZE 4 TO 8 POUNDS OF SOLIDS
- GENERATION OF HEAT
 - DISTORTION OF SOLIDS
 - CAN CAUSE FIRE TO BREAK OUT ON EXTERIOR OF MODULE WALL
- REDUCED VISIBILITY
- ADDITION OF CONTAMINANTS - MOST ARE TOXIC
 - SEVERAL THOUSAND COMPOUNDS WHEN PYROLYZED IN AIR
 - CARBON MONOXIDE MORE LIKELY TO BE PRESENT THAN IN ONE-G
- OVERLOAD OF ATMOSPHERIC REVITALIZATION SYSTEM
 - ADDED STAGNATION IN ZERO-G
- PRESSURE RISE MAY BE CATASTROPHIC
- PYROLYSIS PRODUCTS MAY BE FLAMMABLE
 - LEAKING CONTAINERS CAN SUPPLY FLAMMABLE BASES AFTER FIRE IS EXTINGUISHED
- CORROSIVE RESIDUE

VENTING AS A FIRE-MITIGATION STRATEGY

PROS

- MAY PRECLUDE RUPTURE
- EXHAUSTS TOXIC CONTAMINANTS
- PRECLUDES EXPLOSIVE MIXTURES
- HELPS IN CLEAN-UP OPERATIONS - AVOIDS OVERLOADING ECLSS
- FOR PURE OXYGEN, FIRE SHOULD EXTINGUISH AT ~ .13 PSIA. FOR 21% OXYGEN - FIRE SHOULD EXTINGUISH AT 2-OR 3 PSIA

CONS

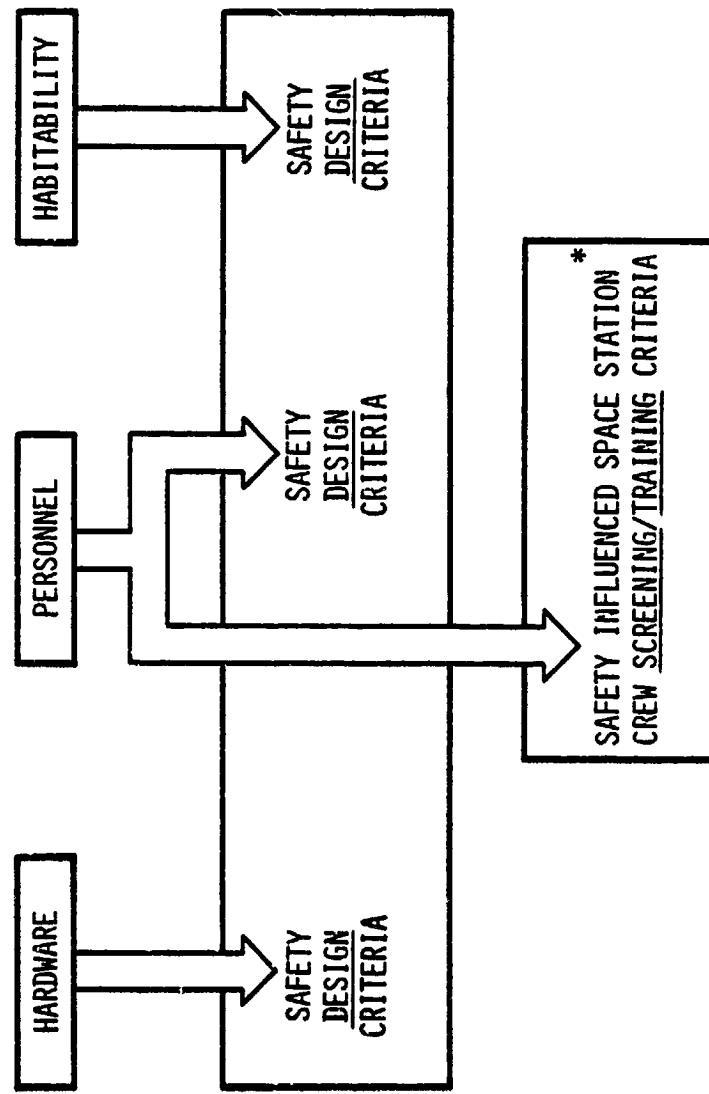
- IF FLAMMABLE LIQUIDS INVOLVED, MORE RAPID BURNING WITH POTENTIAL OF EXPLOSION AT LOWER PRESSURES.
- WHAT IS PROPER RATE OF DEPRESSURIZING A VOLUME? IT VARIES WITH SITUATION.
 - CONVECTION OF VENTING
- ALL CONNECTING PLUMBING MUST BE SEALED.
- TOO RAPID A DEPRESSURIZATION WILL CONDENSE VAPORS, PRODUCE A FOG AND MAY INTENSIFY A FIRE BECAUSE OF HIGH TURBULANCE.
- EXTERIOR DAMAGE - SUBLIMATION ON WINDOWS, RADIATORS, SENSORS, ETC.
- PROPELLIVE VENTING MAY RESULT IN TUMBLING.

THREAT IDENTIFICATION/STRATEGY DEVELOPMENT

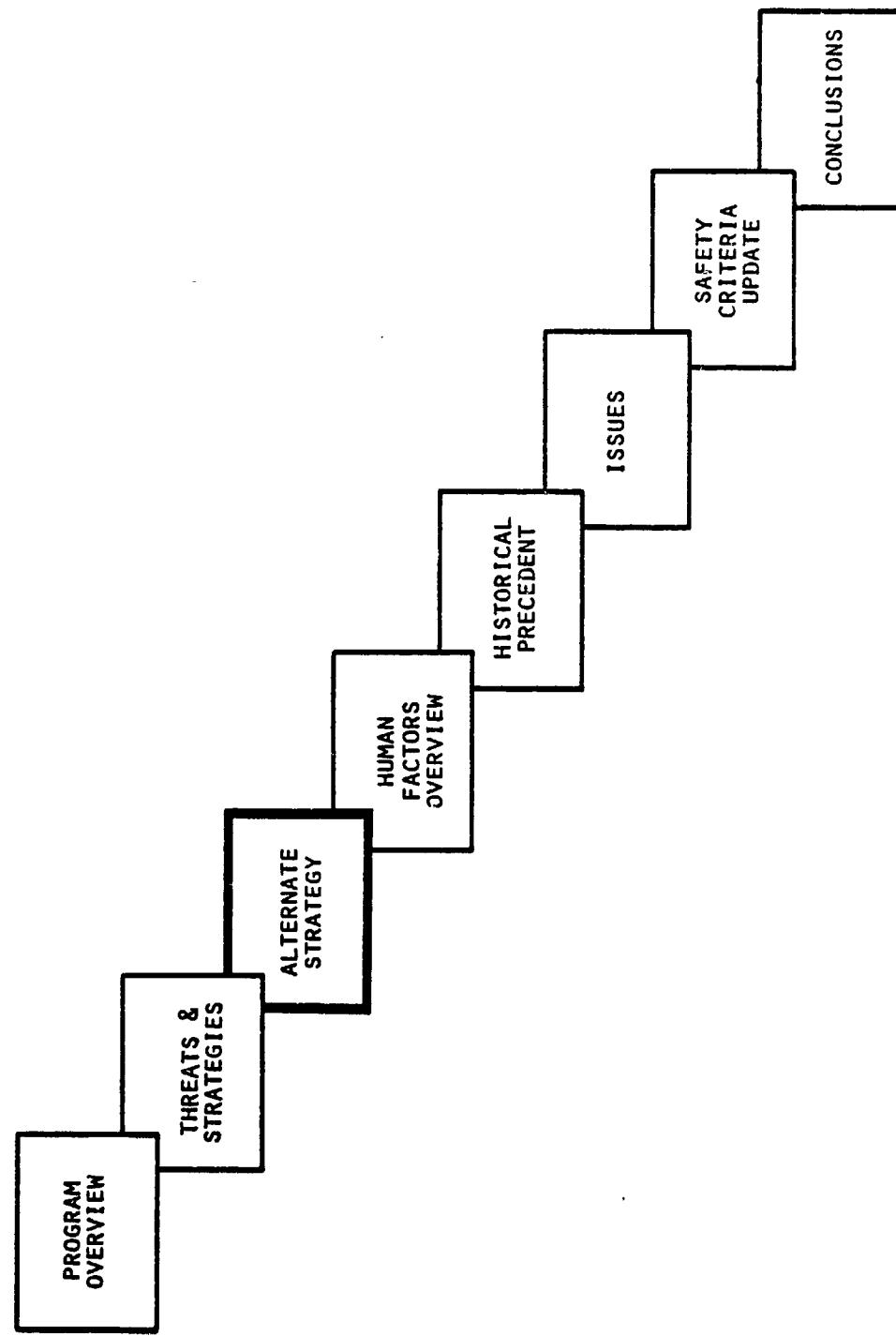
SUMMARY

- 23 THREAT CATEGORIES HAVE BEEN DEFINED
- 8 THREATS HAVE IMPACT TO PRELIMINARY DESIGN & CANDIDATE STRATEGIES WERE DEVELOPED DURING STUDY
- 22 OF THE 23 THREAT CATEGORIES CAN BE DEALT WITH BY PROPER DESIGN SOLUTIONS
- APPROXIMATELY 70 CRITERIA IDENTIFIED TO MITIGATE THREATS
- 50 OF THESE CRITERIA WERE COLLECTED FROM LITERATURE SEARCH
- 20 CRITERIA - SPACE STATION - UNIQUE
- APPROXIMATELY 240 DESIGN GUIDELINES DEVELOPED TO AID IN IMPLEMENTING THE 70 CRITERIA
- MOST THREAT STRATEGIES NEED INCORPORATION AT EARLIEST POINT IN CONFIGURATION DEVELOPMENT TO MINIMIZE DOWNSTREAM HARDWARE/OPERATIONAL IMPACT

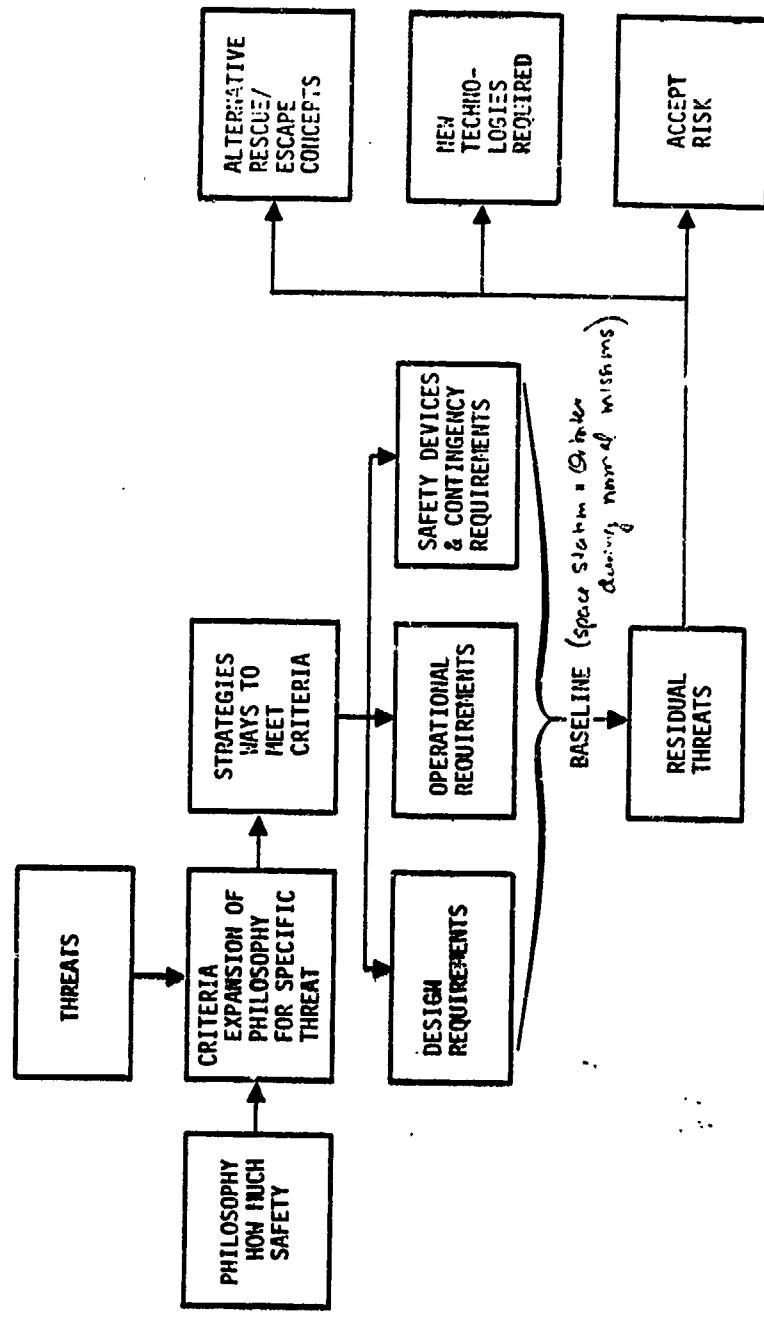
INITIAL HUMAN FACTORS ASSESSMENTS
SAFETY CRITERIA DEVELOPMENT



* HOW IS THIS INCORPORATED INTO SPACE STATION DEVELOPMENT



STUDY APPROACH



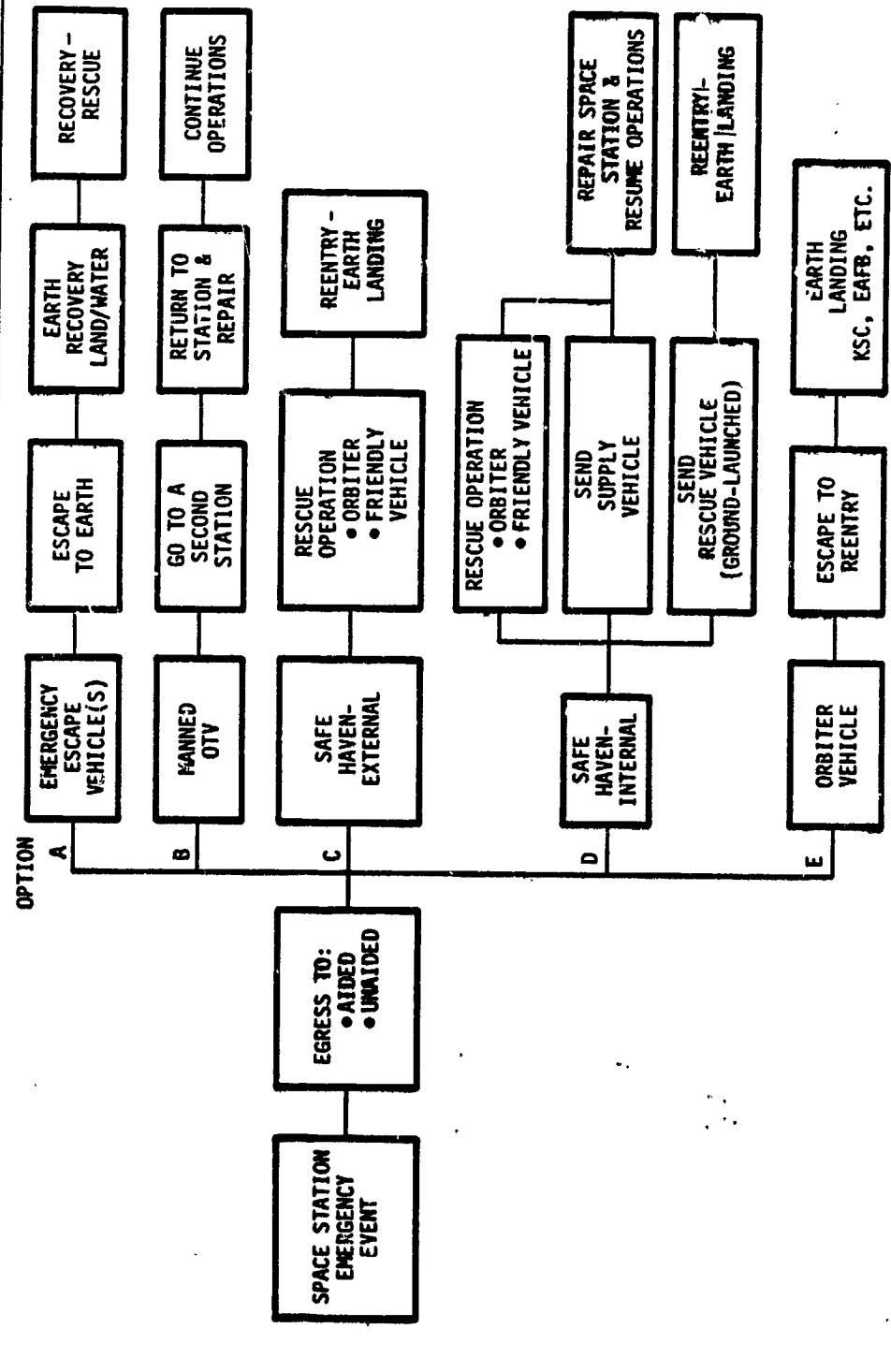
ALTERNATE STRATEGY DEFINITIONS

ESCAPE: LEAVE AREA OF THREAT WITHOUT EXTERNAL AID

RESCUE: AID FROM EXTERNAL SOURCES (EXCLUDING BASELINE)*

*BASELINE: ROCKWELL CONFIGURATION AT BEGINNING OF STUDY
AUGMENTED BY NORMAL SHUTTLE RESUPPLY MISSIONS

ESCAPE AND RESCUE OPTIONS



DISCRIMINATORS FOR ESCAPE/RESCUE SYSTEM OPTIONS

OPTION	COSTS	MISSION CONTINUATION	SAFETY	RESPONSE TIME	CREW SIZE	TECHNOLOGY RISK	TYPE OF CALAMITIES ACCOMMODATED
A EMERGENCY ESCAPE VEHICLES	** NONE 100% (2 VEHICLES MINIMUM) \$300 TO \$1500	100% (2 VEHICLES MINIMUM) \$300 TO \$1500	VARIABLES (10 min TO 1-1/2 hr)	1 TO 4 PER VEHICLE	VERY HIGH	MEDIUM TO VERY HIGH	• FIRE* • TUMBLING* • MECHANICAL DAMAGE • EXPLOSION* • DEPRESSURIZATION* • METEOROID PENETRATION* • DEBRIS *SELECTED
B GO TO A SECOND STATION VIA A MANNED OTV	** NONE NO COST		VARIABLES (15 min TO 1-1/2 hr)	TBD	MEDIUM		ALL OF ABOVE
C SAFE HAVEN EXTERNAL	** NONE TOTAL COST \$300 TO \$500		<1 hr	8	VERY HIGH		ALL OF ABOVE
D SAFE HAVEN INTERNAL	TOTAL COST NO COST		<10 min	8	LOW		ALL OF ABOVE
E CRBITER VEHICLE	NONE <\$1.00/DAY		<15 min	10	VERY LOW		ALL OF ABOVE PLUS INJURY/ILLNESS

**POTENTIAL LOSS OF MISSION

WHAT WOULD CAUSE ESCAPE OF LESS THAN FULL CREW

1 MAN?	2 MEN?	3 MEN?
<ul style="list-style-type: none">• SOLE SURVIVOR	<ul style="list-style-type: none">• TWO SOLE SURVIVORS	<ul style="list-style-type: none">• THREE SURVIVORS (REMOTE PROBABILITY) ESCAPING IMPENDING DISASTER
<ul style="list-style-type: none">• PHYSICAL MEDICAL ISSUE (CUT, SOME BURNS)	<ul style="list-style-type: none">• INDIVIDUAL CREWMAN MEDICAL ISSUE REQUIRING CONSTANT AID BY MEDIC<ul style="list-style-type: none">• PHYSICAL• PSYCHOLOGICAL	<ul style="list-style-type: none">• DECEASED
	<ul style="list-style-type: none">• PSYCHOLOGICAL ISSUE	<ul style="list-style-type: none">• DECEASED

PARAMETRIC EVALUATION ESCAPE, RESCUE, AND SURVIVABILITY CONCEPTS

Concept	Crew Size	Shirt-Sleeve	Technology	Development Risk	Launch Vehicles	Recovery
Escape Airmat	2	No	New	High	No	Water
Rib stiffened	3	Yes	New	High	No	Water
Paracone	1	No	New	High	No	Water
Moose	1	No	New	High	No	Water
Moses	2-4	No	Current	Low	No	Water/air
Encap	1	No	New	High	No	Water
Egress	1	Yes	New	Medium	No	Water
Life raft	3	No	New	High	No	Water
Lifting body	3	Yes	New	Medium	No	Water
EED	3	Yes	New	Medium	No	Water
Spherical heat shield	2	Yes	New	Medium	No	Water
Apollo Escape CM	2-6	Yes	Old	Very Low	No	Water
Saver	1	No	New	Very high	No	Water
Rescue Shuttle	12	Yes	None extra	Low	***	Land
Hermes	Unk	Yes	New	Medium	Yes	Land
Apollo Rescue CSM	2-4	Yes	Current	Low (S-IB)	Yes	Water
Rescue Ball	1	Yes	Current	Low	Med (Titan)	No
Survivability*	1	No	New	High	Only if needed**	Shuttle
Cocoon	12	Yes	Current	Medium	Shuttle	Shuttle
Sortie module	12	Yes	Current	Medium	Shuttle	Shuttle
Space Station Module	12	Yes	Current	Medium	Shuttle	Shuttle
Apollo Survivability CM	8	Yes	Current	Medium	Shuttle	Shuttle
Modular Survivability Vehicle (MSV)	12	Yes	Current	Medium	Shuttle	Shuttle

*Assumes shuttle used for rescue (10 people nominal; greater than 10 in emergency)

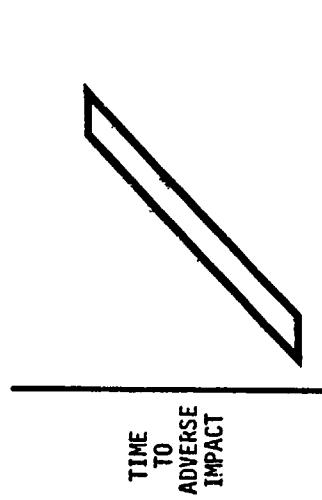
**Low = 2000 kg (4500 lb), high = 4000 kg (9000 lb)

***Launch vehicles are used only if a rescue or survivability situation arises. Dedicated launch vehicles not required.

SPACE STATION CREW SAFETY
THREAT LIST

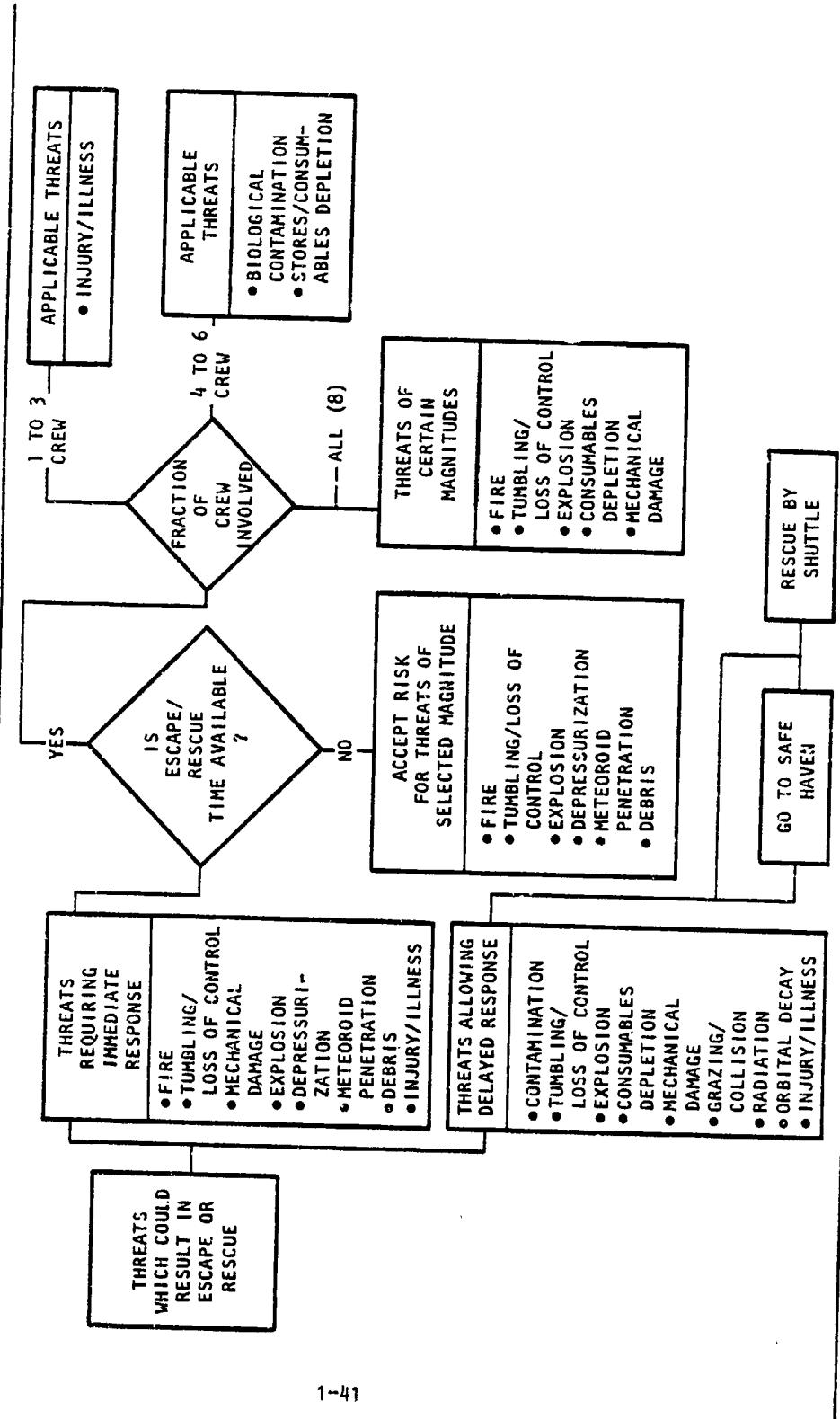
(N/A)	(IM)	(DEL)	TIME TO REPAIR
X	X	X	FIRE
	X	X	LEAKAGE
	X	X	TUMBLING/LOSS OF CONTROL
	X	X	BIOLOGICAL OR TOXIC CONTAMINATION
	X	X	INJURY/ILLNESS
	X	X	GRAZING/COLLISION
	X	X	CORROSION
	X	X	MECHANICAL DAMAGE
	X	X	EXPLOSION
	X	X	LOSS OF PRESSURIZATION
	X	X	RADIATION
	X	X	OUT-OF-CONTROL IVA/EVA ASTRONAUT
	X	X	INADVERTENT OPERATIONS
	X	X	LACK OF CREW COORDINATION
	X	X	ABANDONMENT OF SPACE STATION
	X	X	METEOROID PENETRATION
	X	X	STORES/CONSUMABLES DEPLETION
	X	X	STRUCTURAL EROSION
	X	X	ORBIT DECAY
	X	X	LOSS OF ACCESS TO A HATCH
	X	X	TEMPERATURE EXTREMES
	X	X	DEBRIS
	X	X	FREE ORBIT (EVA ASTRONAUT)

1-40



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THREATS REQUIRING ESCAPE/RESCUE



CANDIDATES FOR ACCEPTED RISKS
(CATASTROPHES OF A CERTAIN MAGNITUDE)

- FIRE RESULTING FROM FUEL CELL, RCS, HYDRAULIC LINE RUPTURE
- IGNITION IN OXYGEN SYSTEM
- RCS CHAMBER OR MANIFOLD EXPLOSION
- DISINTEGRATION OF ROTATING COMPONENTS
- GENERIC SOFTWARE ANOMALY (LOSS OF STABILIZATION & CONTROL)
- LOSS OF CABIN PRESSURE
- CONTAMINATION OF BREATHING ENVIRONMENT
- STRUCTURAL FAILURE OF TANKS
- CONTACT WITH DEBRIS
- LOSS OF STABILIZATION (TUMBLING)

ALTERNATE STRATEGY - SUMMARY

- LIMITS ON USE OF BALLISTIC REENTRY ESCAPE VEHICLES
 - SIZE OF CREW ACCOMMODATED
 - IMPLICATIONS ON NUMBER OF VEHICLES REQUIRED
- LIFE-IN-ORBIT LIMITATIONS
 - PARACHUTES
 - ORDNANCE SYSTEMS (BATTERIES)
 - OTHER DEGRADATION
- (E.G., WOULD ONE TRUST AN ESCAPE POD THAT HAD NOT BEEN USED IN 6 TO 8 YEARS?)
- THREATS ACCOMMODATED BY BALLISTIC REENTRY ESCAPE POD
- LIMITS ON RESCUE SCENARIOS
 - WORST-CASE LIFE SUPPORT REQUIREMENTS
 - 21 DAYS
- THREATS ACCOMMODATED
 - SIZE OF CREW ACCOMMODATED
 - SAFE HAVEN vs RESCUE
 - STORM CELLAR - MINIMUM SURVIVAL CONDITIONS FOR LIMITED PERIOD OF TIME

MAJOR OPEN ISSUES
CREW SAFETY

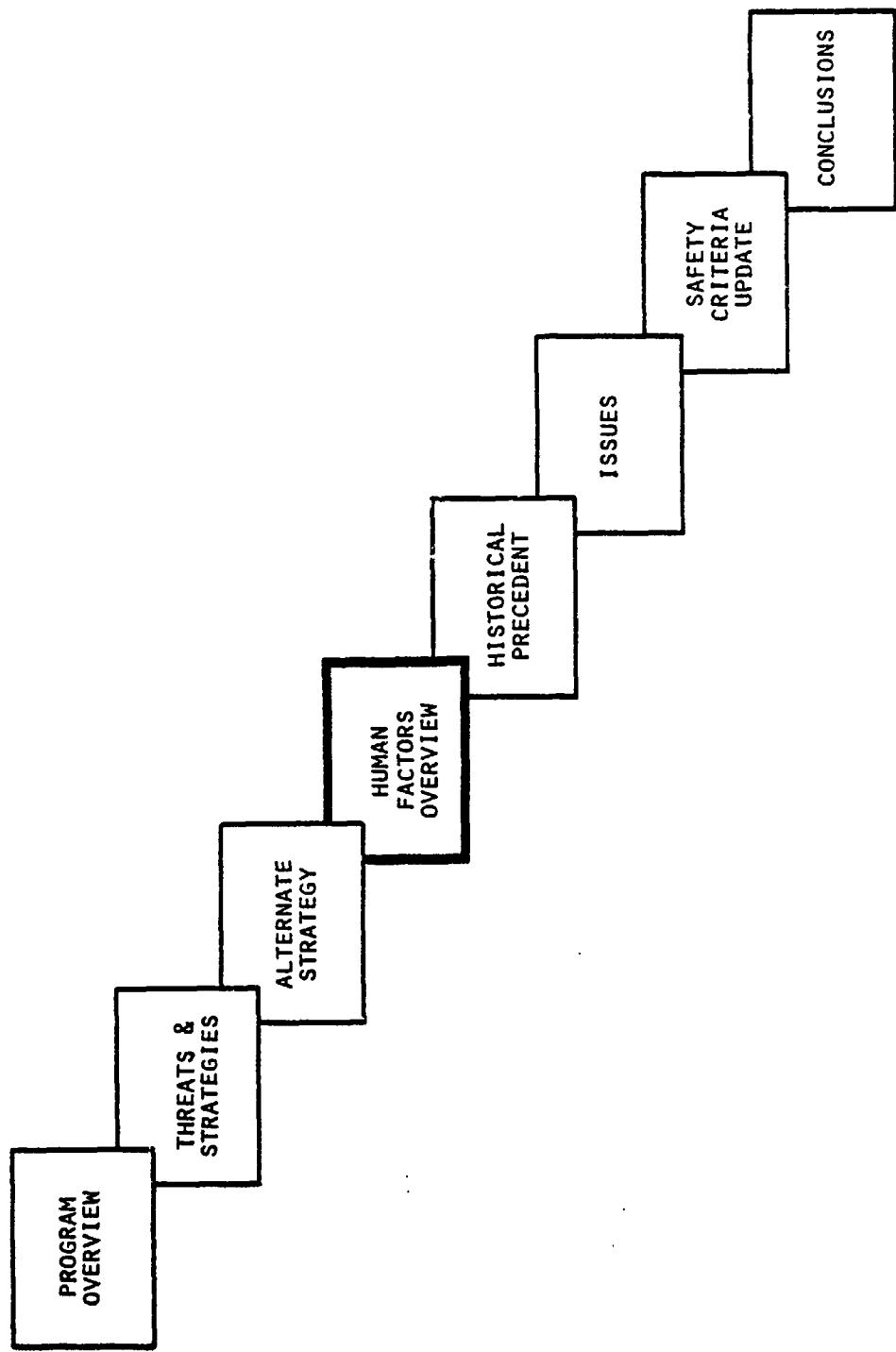
TECHNICAL

- SAFE HAVEN
- LIMITATIONS OF MULTIPLE SAFE HAVENS CONCEPT
- DEPRESSURIZATION
- HOW MANY VOLUME CHANGE-OUTS?
- RESOURCE MODULE CONCEPTS
- MAINTENANCE IN AN UNPRESSURIZED MODULE IS A HIGH-RISK SITUATION
- SINGLE MODULE IS A CONCEPTUAL SINGLE-FAILURE POINT
- DUAL EGRESS REQUIREMENT

PROGRAMMATIC

- MISSION INITIALIZATION IS LIMITED
- TOTAL SYSTEM SAFETY VS INDUSTRIAL SAFETY
 - VARIABLE FACILITY SYNDROME
(by change of cargo)
- TOTAL SYSTEM SAFETY INTEGRATION FUNCTION
- NO PROBLEM REPOSITORY FOR NON-DESIGN CRITERIA

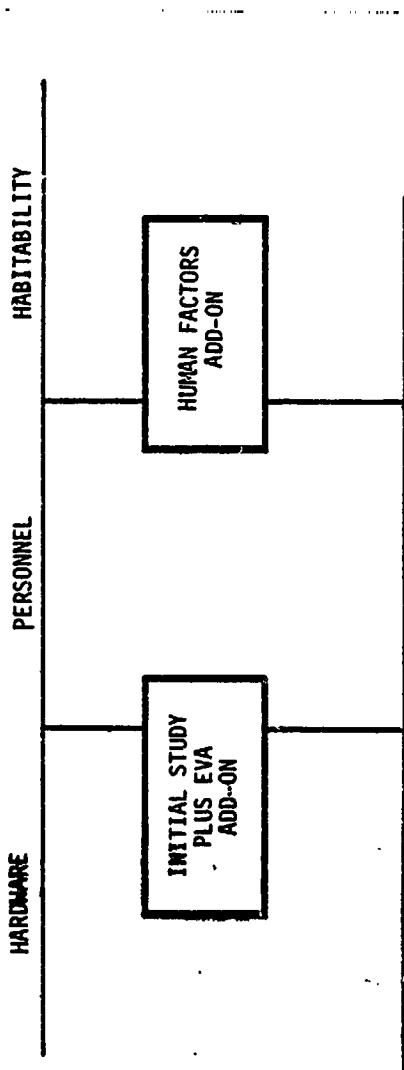
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CREW SAFETY STUDY

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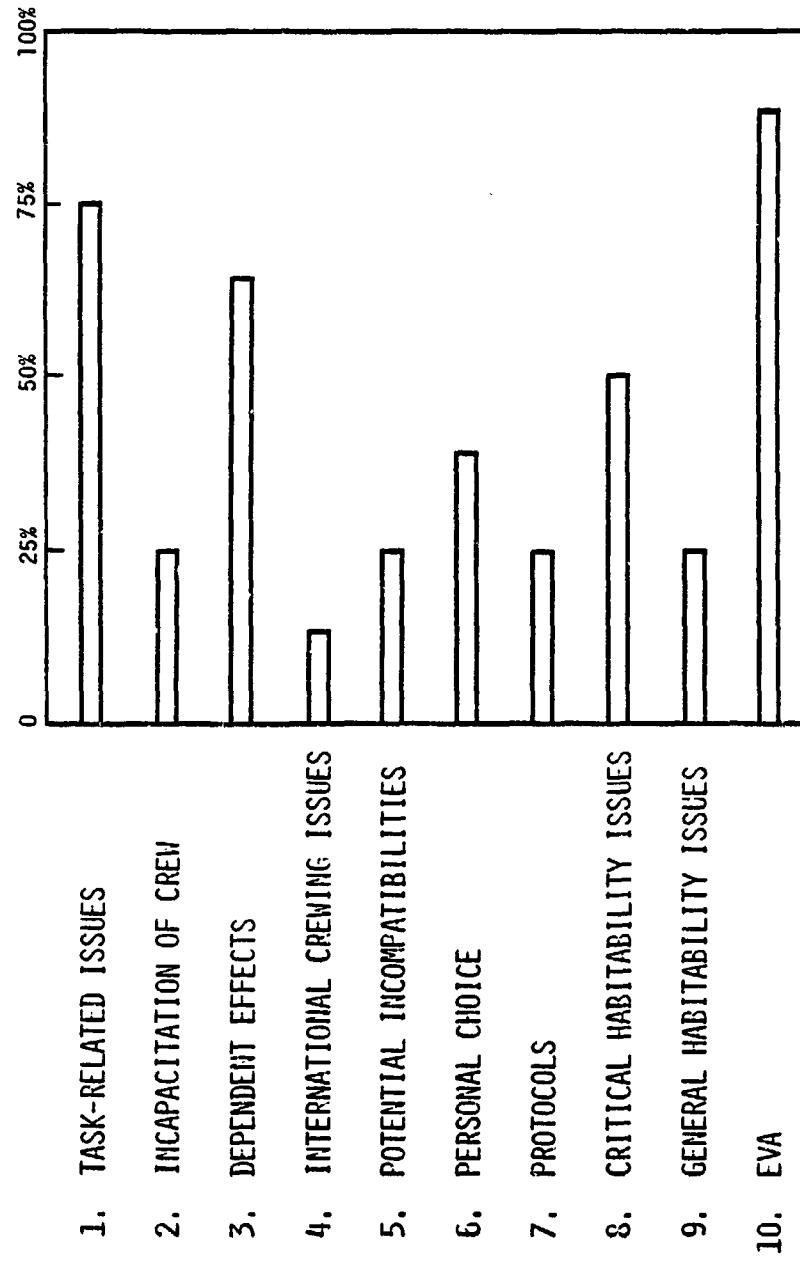
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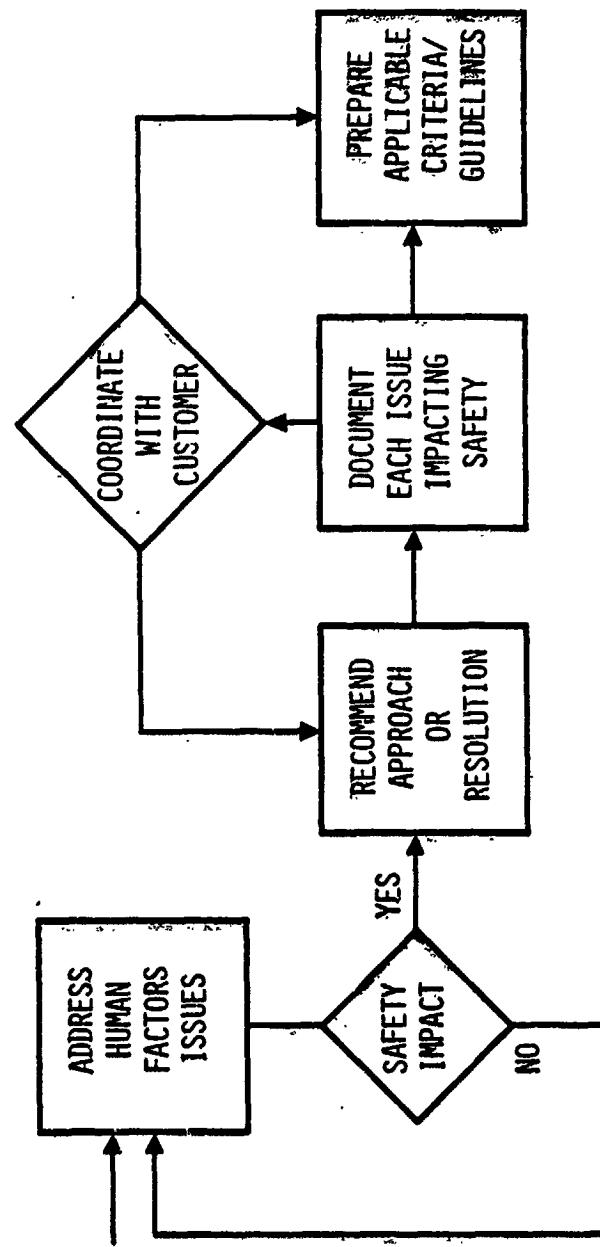
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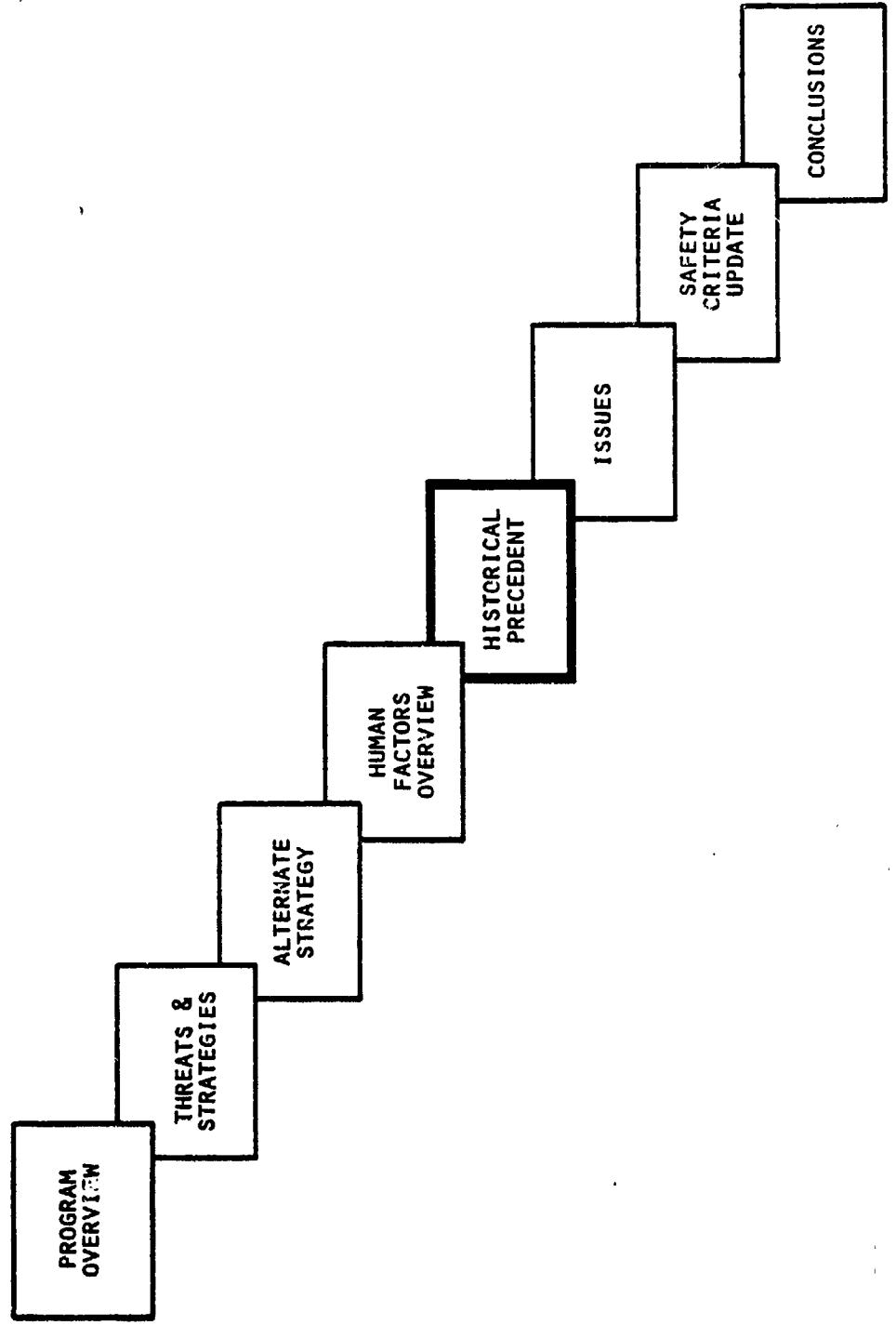
- IDENTIFY SAFETY ISSUES
- PROPOSE CONTROLLING CRITERIA

SPACE STATION SAFETY
HUMAN FACTORS STATUS

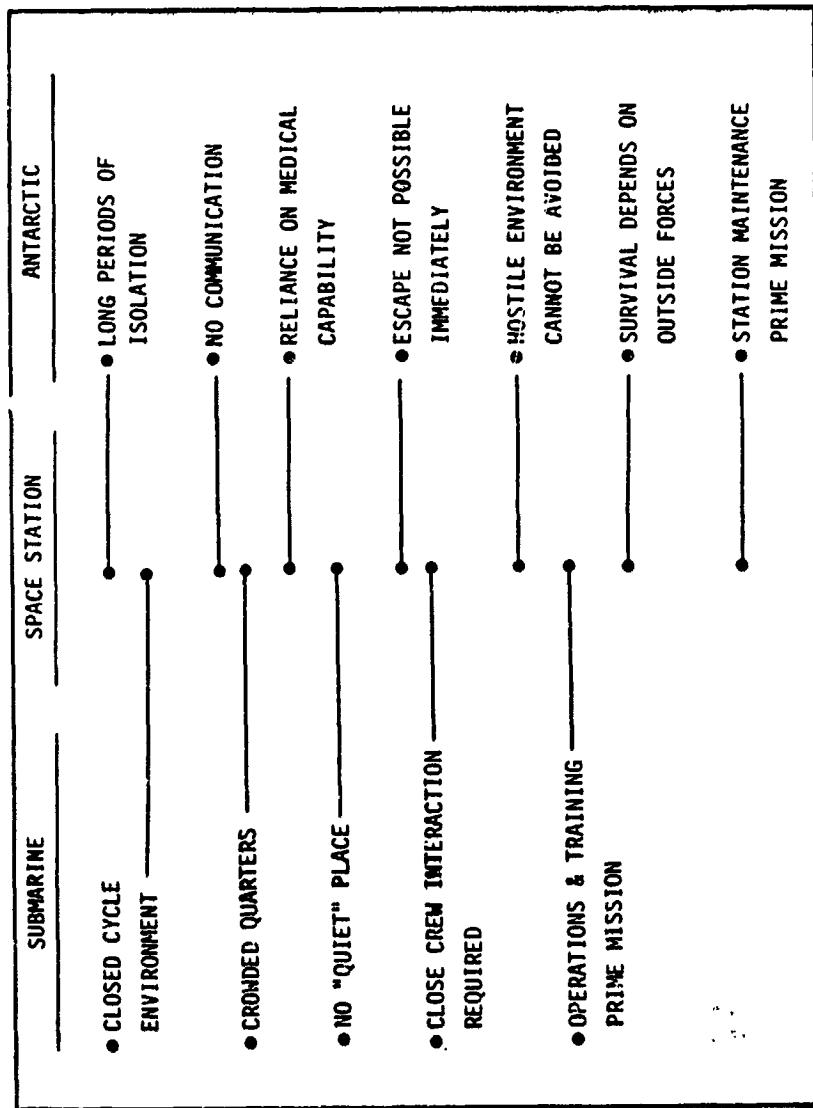


HUMAN FACTORS SAFETY STUDY APPROACH





HISTORICAL PRECEDENT
HUMAN FACTORS ISSUES IMPACT SPACE STATION



NOTE:
MOST SEVERE ISSUES FROM EACH ENVIRONMENT DIRECTLY APPLY TO SPACE STATION

SUBMARINE CREW EFFECTIVENESS DURING SUBMERGED MISSIONS
(60 OR MORE DAYS)

MAJOR STRESSORS:

- CONFINEMENT
- REVITALIZED AIR
- THREAT OF HYPERBARIC EXPOSURE
- FLATTENING OF CIRCADIAN RHYTHMS
- SLEEP DEPRIVATION

MINOR STRESSORS:

- PERFORMANCE DECREMENT
- DEBILITATING MORBIDITY
- DEPRESSED CREW MORALE

BEHAVIOR PATTERNS:

- MOTIVATION vs PSYCHOLOGICAL
 - IN 1961 - 56 OUT OF 126,160 PATROLS HAD PSYCHIATRIC CASUALTIES
 - IN 1963 - 20 PER 1,000

SUBMARINE CREW EFFECTIVENESS DURING SUBMERGED MISSIONS
(60 OR MORE DAYS) (CONT)

SUMMARY COMMENTS:

- BIOLOGICAL ADAPTATION IS A COMPLEX FUNCTION OF:
 - NATURE & ENVIRONMENT SEVERITY
 - ADAPTIVE CAPACITY OF PERSONS INVOLVED
- PARAMETERS FOR SCREENING
 - EFFICIENT PERSONNEL SELECTION, SCREENING & TESTING
 - GROUP INTERACTION PROCESSES TEND TO PRODUCE COHESIVE CREWS
 - QUALITY OF LEADERSHIP INTRINSIC TO & ESSENTIAL FOR CREW INTEGRITY

HISTORY OF MILITARY PSYCHOLOGY
(NAVAL SUBMARINE MEDICAL RESEARCH LAB)

- PSYCHOLOGY - WW II (1942-1945):
 - MAINLY MANDATED BY OPERATIONAL REQUIREMENTS OF DIESEL SUBS
 - RESEARCH IN AREAS OF HEARING, VISION & PERSONNEL SELECTION
 - PRIOR TO ESTABLISHED (NMRL) NAVY MEDICAL RESEARCH LAB
- NUCLEAR-POWERED SUBMARINES:
 - ADDITIONAL PSYCHOLOGICAL PROBLEMS IN CREW SIZE
 - INCREASED DURATION OF SUBMERGED PATROLS (FROM 3 TO 80 DAYS)
 - PSYCHOPATHOLOGICAL EFFECTS OF ISOLATION
 - INCREASED AUDITORY & VISUAL SKILLS
 - ADDED HUMAN FACTORS ASSOCIATED WITH NUCLEAR TECHNOLOGY
 - COLOR-CODED SWITCHES INCREASED COLOR PERCEPTUAL DEFICIENCY TESTS
 - EMPHASIS ON LETTER SCREENING OF PSYCHIATRIC PROBLEMS ASSOCIATED WITH MORALE DETERIORATION. PERFORMANCE DECREMENTS & DEBILITATIVE EFFECTS ON LONG-SUBMERGED MISSIONS
 - DETERMINE OPTIMAL STANDARDS FOR RED LIGHTING
 - POTENTIAL OF HEARING LOSS FROM LONGER EXPOSURE TO SOUND LEVELS
 - FIRST PROBLEMS (72-HOUR SUBMERGE)
 - HEADACHES
 - BLURRED VISION
 - DIZZINESS

HISTORY OF MILITARY PSYCHOLOGY
(NAVAL SUBMARINE MEDICAL RESEARCH LAB) (CONT)

- FIRST PROBLEMS (72-HOUR SUBMERGE) (CONT)
 - MALAISE
 - PERFORMANCE DECREMENTS
- INCREASED INTERRUPTION OF DIURNAL PERIODICITY
 - IN 60- TO 70-DAY RANGE, ALLOWED "PERISCOPE LIBERTY" AT 24-HOUR PERIODS TO ALL CREW (REASSURANCE TO REAL WORLD)
- QUESTION OF: OPTIMIZING "FIT" OF MAN TO ENVIRONMENT OR ORGANIZE ENVIRONMENT TO BEST "FIT" THE MAN?

1c69-1972 (NSMRL):

- CONCERN IN FOUR CONCERNED AREAS
 - HUMAN FACTORS IN SUBMARINE ESCAPE
 - PSYCHO-PHYSIOLOGICAL EFFECTS OF LONG-DURATION EXPOSURE TO SONAR "BEEPS" AT HIGH INTENSITY
 - CENTRAL NERVOUS SYSTEM INDICES OF THE NARCOTIZING EFFECTS OF EXPOSURE TO COMPRESSED GASES
 - DRUG ABUSE IN SUBMARINE SERVICE

HISTORY OF MILITARY PSYCHOLOGY
(NAVAL SUBMARINE MEDICAL RESEARCH LAB) (CONT)

1969-1972 (NSMRL) (CONT)

- LONG CONFINEMENT ADDED MORE ILLNESSES
 - CARDIOVASCULAR
 - RESPIRATORY
 - NEOPLASTIC
- DUE TO ATMOSPHERIC TOXICANTS
- ABSENCE OF SUNLIGHT
- RESTRICTED SPACE

- MOST ALL-PERVERSIVE OF QUESTIONS HAD TO DO WITH ACCUMULATIVE PSYCHO-PHYSIOLOGICAL EFFECTS OF EXPOSURE TO CO₂ AT ABOUT 1.5%
- INTRODUCED DURING "OPERATION HIDEOUT" THAT THE CAPACITY OF CO₂ IN BLOOD GAVE CALCIUM DEFICIENCY
 - COTTAGE CHEESE ADDED TO DIET & MANY TIMES WAS REQUESTED BY CREW AS AN "INSATIABLE DESIRE"

SUMMARY & FUTURE PLANNING:

- IDENTIFICATION & CONTROL OF MAJOR TOXICANTS IN ATMOSPHERE
- DEVELOP & VALIDATE AN EFFECTIVE PSYCHOLOGICAL SCREENING PROGRAM
- APPLY CONCEPT OF "SIGNIFICANT ADAPTIVE DECREMENT"
 - LD-50 (LETHAL DOSE IN 50% OF EXPOSED POPULATION) & SAD-50 (STRESSOR CLASS LD-50) - LEVELS OF TOXIC GAS, LENGTH OF DUTY CYCLE, DURATION OF SLEEP DEPRIVATION

REF: U.S. NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY (245)

ANTARCTICA

- A FACTOR CONTRIBUTING TO THE IMPORTANCE OF INTERMEMBER ATTRACTION FOR GROUP EFFECTIVENESS IS THE NATURE OF THE SETTING
- BESIDES SPACE, ANTARCTICA IS ONE OF THE MOST HOSTILE ENVIRONMENTS INHABITED BY MAN
- DURING THE ISOLATION PERIOD, SURVIVAL DEPENDS ON EACH STATION GROUP'S ABILITY TO HANDLE ANY EMERGENCIES THAT MIGHT ARISE
- THIS SETTING IS RELATIVELY STRESSFUL & UNDER CONDITIONS OF STRESS, INDIVIDUALS MAY TEND TO BECOME MORE ANXIOUS, INTERDEPENDENT & AFFILIATIVE
- ANTARCTICA SYMPTOMS FOUND TO BE:
 - DEPRESSION
 - INSOMNIA
 - ANXIETY
 - HOSTILITY
- STRESS, UNCLEAR GOALS, & A COMBINATION OF TASK & SOCIAL-EMOTIONAL ORIENTATIONS HAVE BEEN FOUND TO BE PRESENT IN THE ANTARCTICA SETTING

REFERENCE: NAVAL HEALTH RESEARCH CENTER (256)

SCREENING PROCEDURES FOR ANTARCTICA

- THREE MAJOR TYPES OF SCREENING INFORMATION USED
 - CLINICAL EVALUATION BY PHYSIOLOGISTS & PSYCHIATRISTS
 - BIOGRAPHICAL INFORMATION
 - ATTITUDE & PERSONALITY TESTS
- IN ANTARCTICA RESEARCH, BIOGRAPHICAL INFORMATION HAS BEEN USED FOR THREE PURPOSES:
 1. TO PREDICT INDIVIDUAL ADJUSTMENT OR PERFORMANCE
 2. TO DIFFERENTIATE OCCUPATIONAL SUBGROUPS IN TERMS OF EDUCATIONAL, FAMILIAL, SOCIAL & CULTURAL BACKGROUND CHARACTERISTICS
 3. TO PREDICT GROUP COHESIVENESS OR COMPATIBILITY ON THE BASIS OF DIVERSITY OR SIMILARITY IN BIOGRAPHICAL CHARACTERISTICS
- ATTITUDE QUESTIONNAIRE DESCRIBING MOTIVATION FOR THE ANTARCTIC ASSIGNMENT, CONFIDENCE IN EXPEDITION LEADERSHIP, SATISFACTION WITH DUTY & REACTIONS TO COLD WEATHER, FOOD & CLOTHING WAS ADMINISTERED IN THE SCREENING PROGRAMS
- PSYCHIATRIC EVALUATIONS WERE INTENDED ONLY TO IDENTIFY & DISQUALIFY POTENTIAL PSYCHOTIC OR SERIOUSLY DISTURBED INDIVIDUALS

REF: NAVY MEDICAL NEUROPSYCHIATRIC RESEARCH (255)

LESSONS LEARNED - SKYLAB

- SKYLAB MISSIONS, AS WELL AS APOLLO/LEM, APOLLO/SOYUZ, & APOLLO/SKYLAB PROVIDED AN OPPORTUNITY TO EVALUATE THE DESIGN FEATURES & PROCEDURES THAT ARE REQUIRED TO ALLOW AN ASTRONAUT TO FUNCTION IN SPACE

FINDINGS:

- NORMAL CREW MOVEMENTS DO NOT CAUSE UNWANTED PHYSICAL DISTURBANCES IN MOST EXPERIMENTS
- SOME LIMITATIONS STILL MAY BE REQUIRED ON CREW MOVEMENTS DURING CRITICAL PHASES OF THE EXPERIMENT
- SUGGESTS THAT IN FUTURE FACILITIES, PERMANENT HARDWARE SHOULD HAVE NO NOOKS & CRANNIES THAT WOULD PRECLUDE THE RETRIEVAL OF LOOSE ITEMS THROUGH THE "AIR-RETURN" PHENOMENON
- FUTURE DESIGNS SHOULD ALLOW THE CREW ACCESS TO ANY POINT ON THE EXTERIOR OF THE SPACECRAFT FOR PURPOSES OF INSPECTION OR UNSCHEDULED MAINTENANCE & REPAIR
- ARCHITECTURAL LAYOUT OF THE SPACECRAFT'S INTERIOR SHOULD ENSURE THAT NORMAL TRAFFIC ROUTES DO NOT INTERFERE WITH THE ACTIVITIES OF OTHER CREWMEN
- IT WAS FOUND THAT A PRE-SLEEP PERIOD OF AT LEAST ONE HOUR OF MENTALLY NONDEMANDING ACTIVITY WAS REQUIRED
 - THIS ALLOWED THE CREW TO RELAX TO THE POINT WHERE THEY COULD FALL ASLEEP

LESSONS LEARNED: SKYLAB (CONT)

- THERE WAS AN OCCASIONAL NEED FOR PRIVATE COMMUNICATIONS
 - A SECURE COMMUNICATION LINE SHOULD BE PROVIDED IN FUTURE SYSTEMS TO ELIMINATE POTENTIAL MISQUOTEING OR MISUNDERSTANDING
- SLEEP COMPARTMENT VENTILATION SHOULD FLOW IN A HEAD-TO-FOOT PATTERN
- RIGID ADHERENCE TO A TWO-HOUR DAILY EXERCISE ROUTINE HAS BEEN CITED BY SOVIET AEROSPACE MEDICAL PERSONNEL AS THE PRIME FACTOR THAT ALLOWED A SALYUT-6 CREW TO RETURN TO EARTH IN STRONG PHYSICAL CONDITIONS
- THE SHOWER BATH FACILITY USES A PORTABLE SPRAY HEAD, BUT THE METHOD OF WATER REMOVAL AFTER USE WAS NOT CONVENIENT & CONSIDERABLE EFFORT & TIME WERE REQUIRED TO SET UP & TAKE DOWN THE SHOWER
- AN ENCLOSED HAND WASHER THAT WOULD ALLOW HAND INSERTION & ACTUAL "WORKING" DIRECTLY WITH THE WATER WOULD BE DESIRABLE
- CREW SHOULD BE PROVIDED WITH FAMILIAR "UP" & "DOWN" REFERENCES, PERMITTING EASY ORIENTATION, LOCATION RECOGNITION & EQUIPMENT IDENTIFICATION
- ILLUMINATION LEVELS MATCHING THOSE OF NORMAL EARTH WORKING CONDITIONS SHOULD BE PROVIDED

STS-9 CREW DEBRIEFING

Spec. 1-6

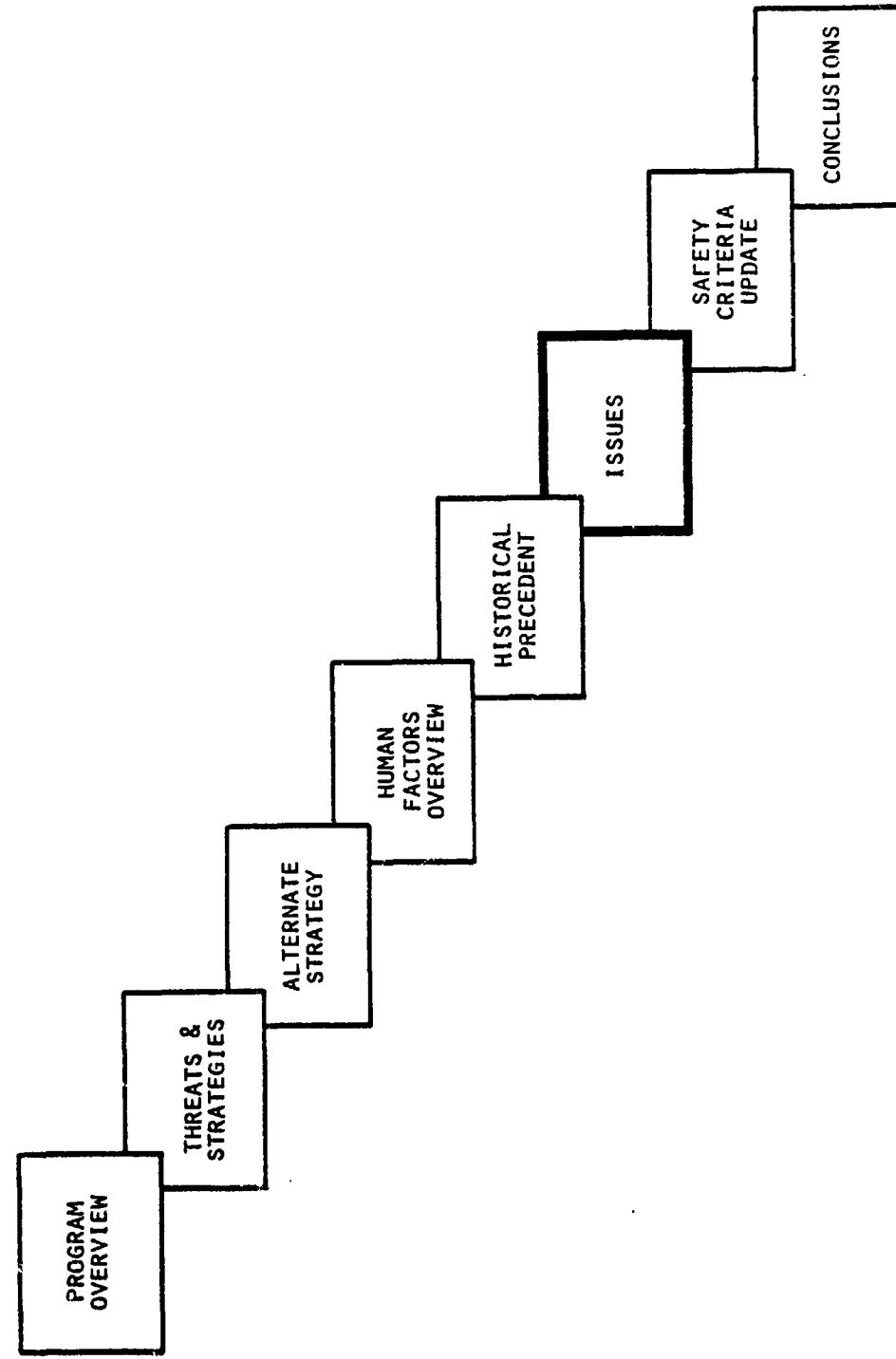
TWO-SHIFT OPERATIONS

- MULTIPROBLEMS ON FLIGHT DECK/MID DECK SATURATES QUICKLY
- BECOMES CLOCK-WATCHING ROUTINE
- AUTOMATE SOME OF THE MANEUVERS
- SUGGESTIONS: 12-13 MANEUVERS PER SHIFT NORMAL
20 MAXIMUM PER SHIFT

- ON TWO-SHIFT (12 & 12), A SECOND FLIGHT DECK CREWMAN NEEDED
- TREADMILL COULD NOT BE USED WHILE OTHER SHIFT ASLEEP
- B. SHAW - PRESENTED THE FOLLOWING COMMENTS:
 - HE THOUGHT IT WAS A LARGE STRAIN ON THE CREW, BUT CAN BE DONE IF REQUIRED
 - CDR & PILOT TASKS - REQUESTED 3 PEOPLE FOR FLIGHT DECK OPERATIONS
 - THIS WOULD ENABLE THEM TO GO ON 8-HOUR DUTY CYCLES

SAFETY IMPACT

- CONCERN HERE IS FOR CONTINGENCY OPERATIONS
- WITH THREE FLIGHT DECK CREWMEN ON 8-HOUR SHIFTS:
 - THE PILOT WOULD NOT BE TIRED
 - WOULD NOT HAVE TO AWAKEN THE OTHER CREWMEN
 - THE OFF-DUTY CREWMAN WHO IS AWAKE CAN PROVIDE ASSISTANCE FOR ANY CONTINGENCY OPERATION



MAN-MACHINE INTERFACES - ARCHITECTURE
TERRITORIALISM

ISSUE

- CLASSICAL ANTHROPOMETRICS MEASURES SCOPE OF EXPECTED BODY DIMENSIONS TO PROVIDE DESIGNERS WITH DISCRETE REQUIREMENTS FOR INTERFACING EQUIPMENT DESIGN. THE PSYCHOLOGICAL NEED FOR EACH INDIVIDUAL'S INTERACTIVE "SPHERE" IS NOT EASY TO DEFINE. VIOLATION OF ONE'S PERSONAL "SPHERE" GENERATES HOSTILITIES (REAL OR PERCEIVED) BETWEEN INDIVIDUALS. THIS ISSUE TENDS TO RESIST RESOLUTION

SAFETY IMPACT

- VIOLATION OF CREWMAN'S VOLUME TENDS TO DEVELOP ANTAGONISMS THAT COULD ERUPT INTO EVENTUAL INTERCREW HOSTILITIES

APPROACH

- DEVISE MENSURATION METHODS THAT CAN DEFINE THE LIMITS OF ONE'S "SPHERE":
 1. PROVIDE DESIGNERS WITH OPTIMUM DIMENSION, & 2. SCREEN OUT POTENTIAL STATION CREW PERSONNEL WHOSE SPHERE SIZE EXCEEDS THAT SELECTED FOR STATION DESIGN

ANTHROPOMETRICS

ISSUE

- PHYSICAL CAPABILITY TO HANDLE 5TH PERCENTILE FEMALE UP THROUGH 95TH PERCENTILE MALE IS DESIGN ISSUE

- SOME OF THESE ISSUES WERE NOT READILY RESOLVABLE - WORK STATIONS LARGE ENOUGH ON ONE END OF THE SPECTRUM, YET SMALL ENOUGH FOR A 5TH PERCENTILE FEMALE TO REACH ALL CONTROLS & DISPLAYS

APPROACH

- ENSURE THAT CRITICAL & EMERGENCY CONTROLS & DISPLAYS ARE IN CORE REACH & SIGHT VOLUME

CRISIS MANAGEMENT

ISSUE

- ANNUNCIATING EVENTS FROM MANY STIMULI ARE COUNTERPRODUCTIVE
- THE THREE MILE ISLAND INCIDENT MAY HAVE BEEN PRECIPITATED BY MULTIPLE ANNUNCIATIONS THAT CONFUSED THE OPERATORS
- SHUTTLE USES THREE-LEVEL SYSTEM
 - MASTER ALARM - HARDWIRED
 - C&W PANEL - HARDWIRED/REDUNDANCY MGT
 - BLUE LITE ALERT - SYSTEMS MANAGEMENT (SOFTWARE)
- B-1B USES ANNUNCIATION & A CENTRAL INTEGRATED TESTING SUBSYSTEM

SAFETY IMPACT

- SENSORY OVERLOAD IS PRECURSOR TO DISASTER

APPROACH

- CONTROLS & DISPLAYS SHOULD INCLUDE CONTINGENCY LEVEL INDICATORS, EDIT FUNCTIONS & MAINTENANCE ACTION READOUTS
- SCREEN FOR "UNFLAPPABLE" CREW

EMERGENCY PROCEDURES

ISSUES

- COMPLETE LOSS OF EQUIPMENT FUNCTIONS AND/OR PARTIAL DISABILITY
- REDUNDANT SYSTEMS
- NUMBER/TYPE WARNING SYSTEMS
- FIRE OR OTHER CATASTROPHIC INCIDENT
- LOSS OF PERSONNEL (DEATH) & INJURY
- EGRESS ROUTE & SAFE HAVEN
- ESCAPE & RESCUE

SAFETY IMPACT

- EMERGENCY PROCEDURE CUEING & IMPLEMENTING OVERLOAD IS RISK SITUATION

APPROACH

- ASSESS MAJOR ENVIRONMENTAL MANAGEMENT & LIFE SUPPORT SYSTEMS
- RECOMMEND REDUNDANCY WITHOUT "OVERKILL"
- IDENTIFY WARNING SYSTEMS - VISUAL & AUDIBLE
- DUAL EGRESS & SAFE HAVEN FOR EACH MODULE/CAPSULE
- PROPER PROCEDURES FOR DOCKING, EVA & INTERVEHICULAR ACTIVITIES
- ADEQUATE TRAINING OF PERSONNEL
- PORTABLE EMERGENCY EQUIPMENT

CLEANING/DISINFECTING

ISSUES:

- IDENTIFY PRIMARY & SECONDARY AREAS OF CLEANING
- GROUP BY PRIORITY. HEALTH & HYGIENE, GENERAL HOUSEKEEPING, HARDWARE, CLEAN ROOMS, ETC.
- MATERIALS & METHODS TO BE UTILIZED WITHOUT CREATING ADDITIONAL PROBLEMS
- ESTABLISH MAINTENANCE ITEMS & REGULARLY SCHEDULED ACTIVITIES
- WILL ALL CREW MEMBERS ROTATE TASKS TO PREVENT BOREDOM & CLASS DISTINCTION?

SAFETY IMPACT:

- PERSONNEL HEALTH EFFECTED BY REVITALIZED AIR SYSTEMS & CONTROL OF TOXICITY
- MORALE FACTORS DEPLETED BY ASSIGNMENTS TO SPECIFIED INDIVIDUALS
- CERTAIN LAB EXPERIMENTS MUST BE CONTROLLED TO PROTECT OTHER CREW MEMBERS
- PHYSICAL DEGRADATION DUE TO SLEEP DEPRIVATION BIOLOGICAL PROCESSES, WHICH ARE A RESULT OF ESTABLISHED ENVIRONMENTAL CONTROL METHODS
- GOOD DETERGENTS IMPACT ECSS SYSTEM DESIGN (LiOH)

APPROACH:

- DETERMINE CLEANLINESS/DISINFECTANT LEVELS FOR ISOLATED & CONFINED LIVING/WORKING AREAS
- INVESTIGATE HIGH-TECH FILTRATION SYSTEMS TO CONTROL REVITALIZED AIR SYSTEMS
- MANDATE NO INDIVIDUAL "GRUNT" WORK, BUT SHARED CLEANING/MAINTENANCE ACTIVITIES
- INVESTIGATE ADDITIONS TO DIET AND/OR VITAMIN/MINERAL INTAKE TO "OFFSET" LOSSES IN REVITALIZED AIR

MISSION SCHEDULING

ISSUE:

- SCHEDULING CRITERIA MAY BE FORCED BY ECONOMIC (NUMBER OF SHUTTLE FLIGHTS), POLITICAL (INTERNATIONAL PARTICIPANTS), COSMIC (WINDOWS FOR EXPERIMENTS), & PERSONNEL PHYSIOLOGICAL/PSYCHOLOGICAL, SO. 2-2, 1- ENBURANCE

SAFETY IMPACT:

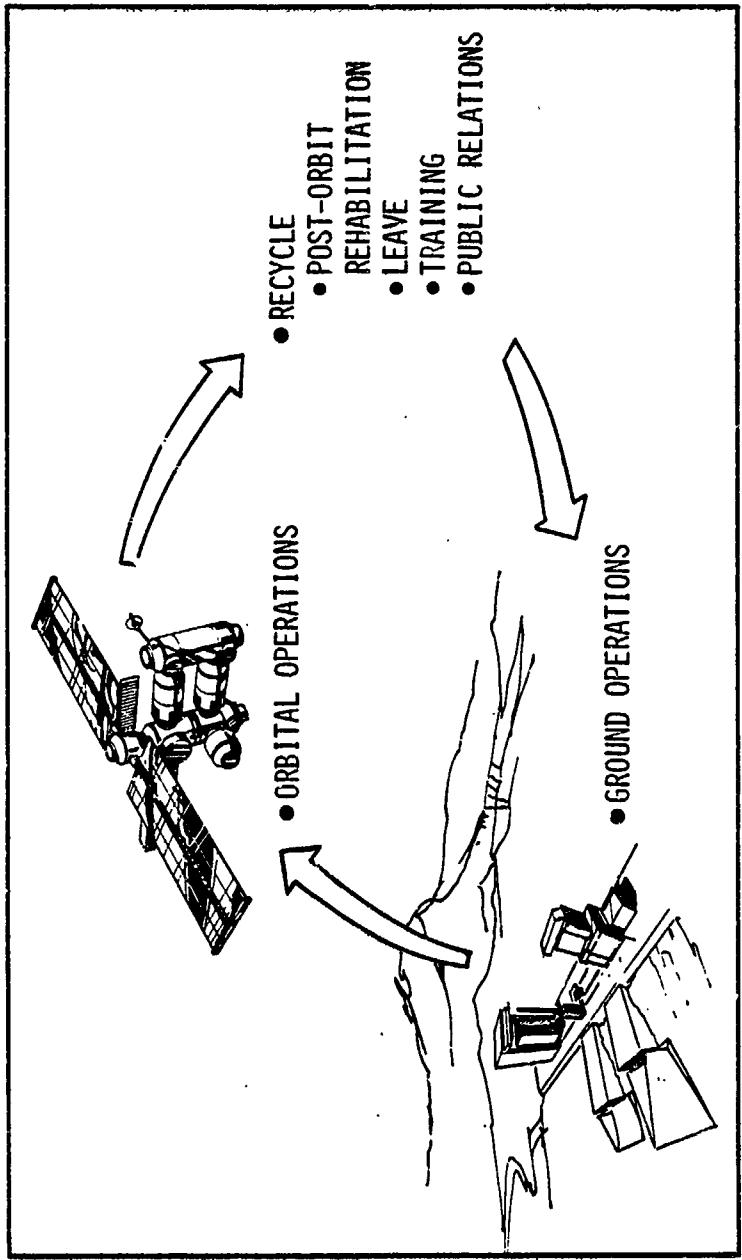
- CREW FATIGUE, ILLNESS, IRRITABILITY & TIME PRESSURES DRIVE PEOPLE TO MAKE ERRORS OR FUNCTION OUTSIDE OF EXPECTED PARAMETERS

APPROACH:

- SET UP INTEGRATED AIR-GROUND TEAMING
- CUT DOWN TOTAL PER-PERSON TIME ON ORBIT BUT APPLY EFFORT TO STATION MISSIONS
- MAKE RATIONAL ASSESSMENTS OF MAXIMUM ALLOWABLE TIME IN ORBIT RECOMMENDED PER YEAR (RADIATION, PHYSICAL DEBILITATION, PSYCHOLOGICAL ABERRATION)

WORK GROUP/SHIFT DYNAMICS

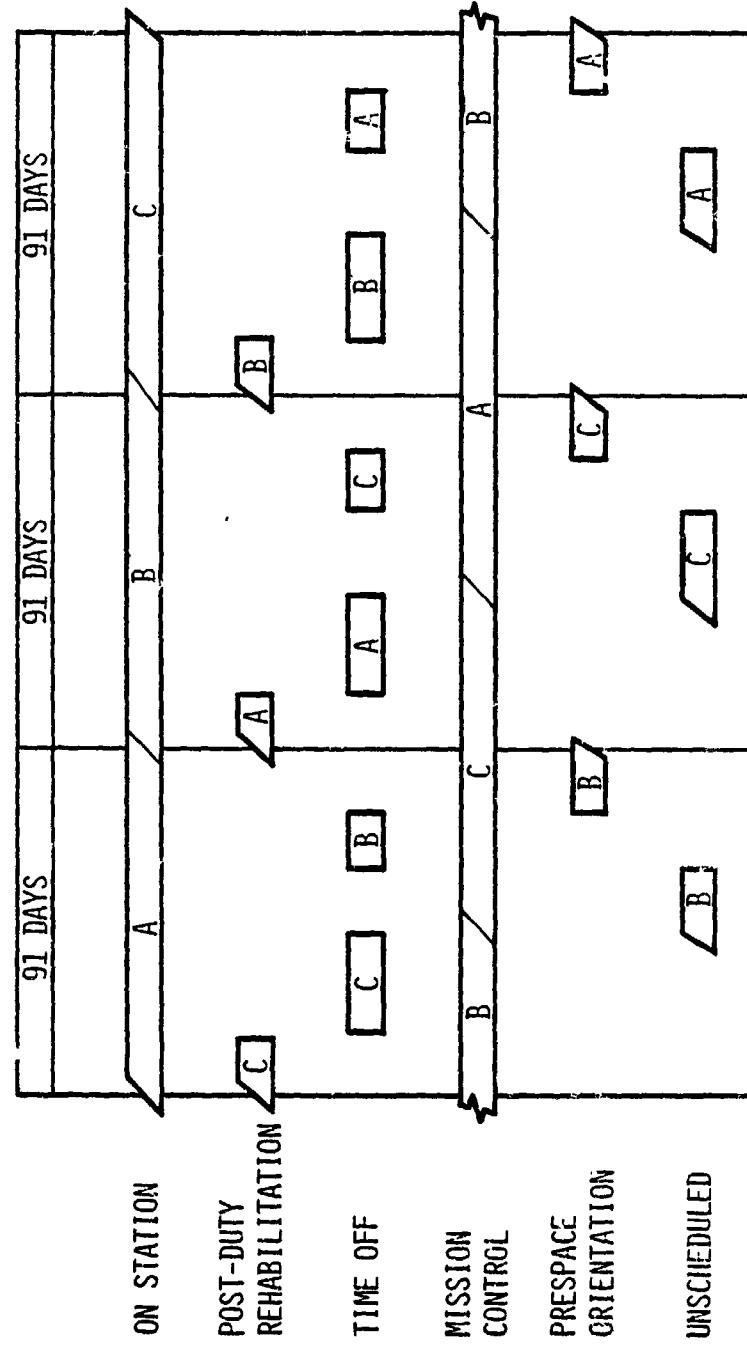
• USE "AGGRGATE" TEAM CONCEPT



• ONE THIRD OF TIME SPENT IN EACH MISSION SEGMENT

SURFACE HABITAT SCHEDULING - PERSONNEL

THREE CREWS WOULD HANDLE ALL ASPECTS OF SPACE HABITAT



CREW CHANGEOVER

ISSUE:

- SPACE STATION IS SIZED FOR ONE CREW (8-16 PEOPLE). WHEN CREWS CHANGE OVER, WHERE WILL THE SECOND CREW BE & HOW LONG ON STATION?

SAFETY IMPACT:

- CONTINGENCY PLANNING MAY NOT BE ABLE TO HANDLE TWO CREWS

APPROACH:

- BEGIN CHANGEOVER ON GROUND
- MAINTAIN ORBITER AT STATION DURING CHANGEOVER
- PREPARE DETAIL PLAN FOR STATION CONTINGENCY OPERATIONS DURING CHANGEOVER

CROSS-TRAINING

ISSUE:

- EIGHT-MAN CREW TO HANDLE ALL SPACE STATION MAINTENANCE, OPERATIONS, USER SET-UP, MAINTENANCE & OPERATIONS REQUIRES BROAD, OVERLAPPING CAPABILITIES AMONG CREW

Requires 5 crew members for 2 crew positions: 1/2 man, 1/2 man, 1/2 man, 1/2 man.

SAFETY IMPACT:

- UNIQUE CRITICAL SKILLS ARE LIABILITIES IF CREW MEMBER BECOMES INCAPACITATED

APPROACH:

- SCREEN TOWARD GENERALISTS vs SPECIALISTS
- AUTOMATE, USING REDUNDANCY & SIMPLE MAINTENANCE REQUIREMENTS EQUIPMENT, EXPERIMENTS OR PRODUCTION LINES REQUIRING UNIQUE SKILLS

NOTE: APPROXIMATELY 50% OF SKYLAB CREW TIME WAS SPENT IN STATION UPKEEP, HOUSEKEEPING & REPAIR.

ACOUSTICAL IMPACTS

ISSUES:

- NOISE LEVELS FROM SPACECRAFT SYSTEMS/COMPONENTS
- PERSONNEL PHYSICAL & MENTAL EFFECTS
- BACKGROUND NOISE
- UHF NOISE
- CONTROLS, REDUCTION AND/OR ELIMINATION

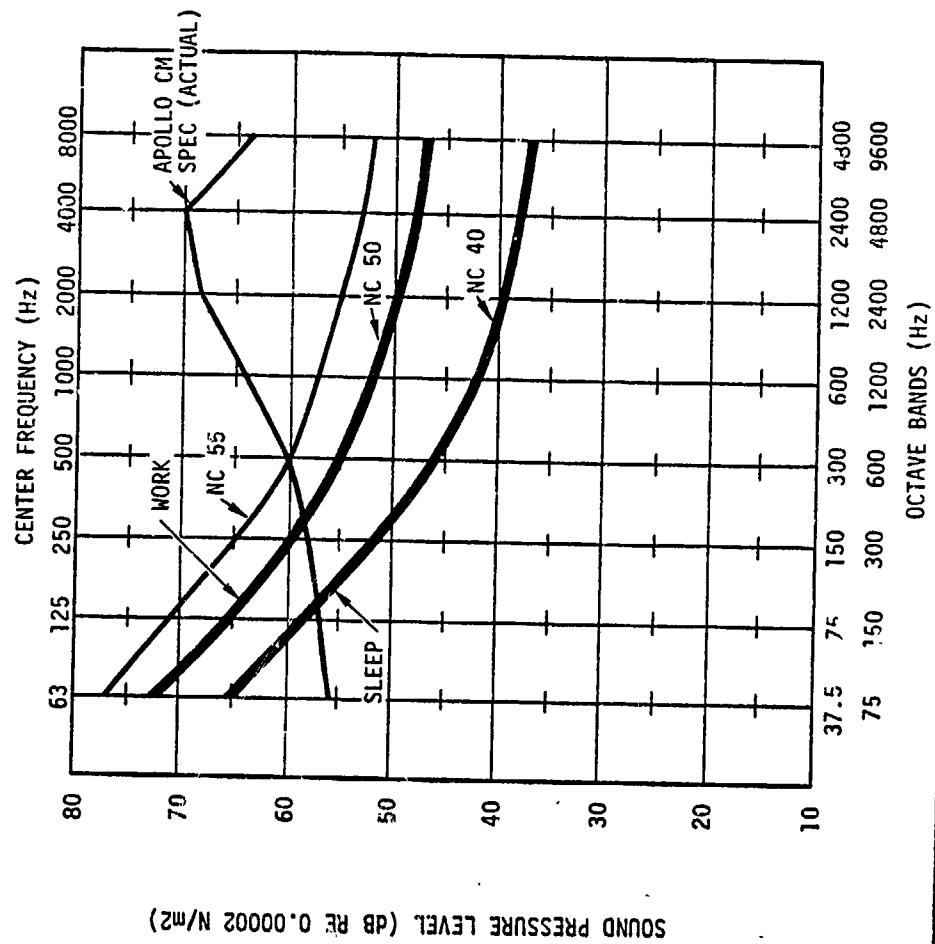
SAFETY IMPACTS:

- CREW FATIGUE, IRRITABILITY & INABILITY TO COMMUNICATE ARE RISK GENERATORS

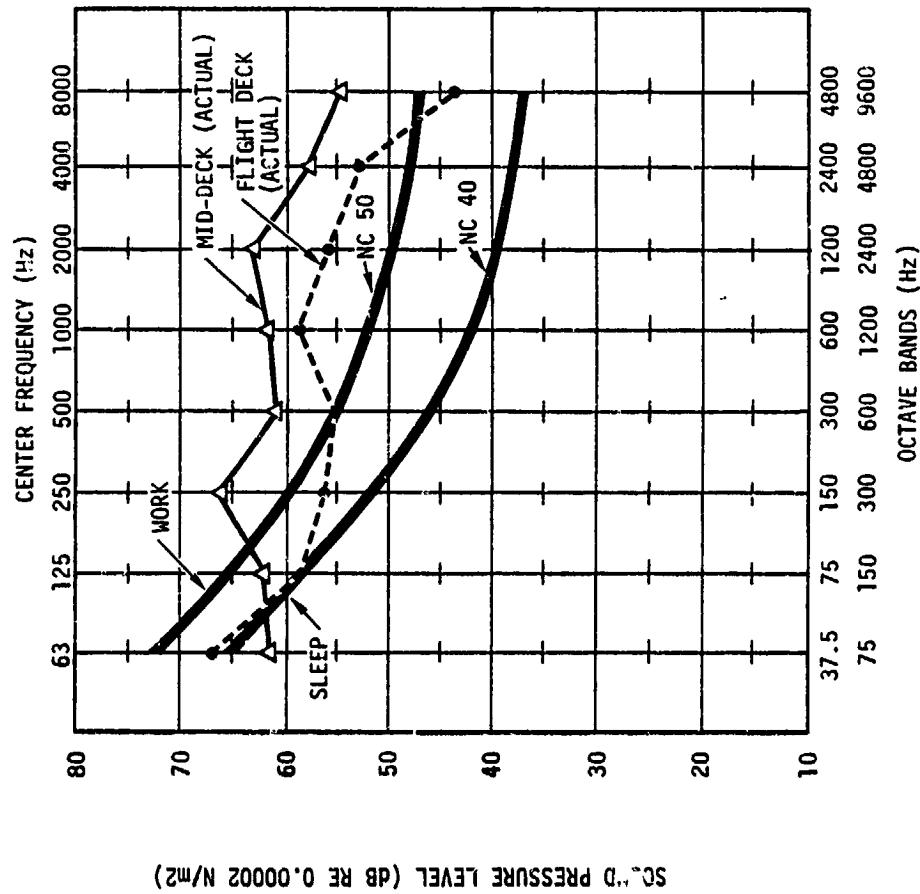
APPROACH:

- MEASURE & ASSESS ALL NOISE SOURCES FOR DB LEVEL & FREQUENCY
- INCLUDE INDIVIDUAL & ACCUMULATED NOISE
- INVESTIGATE CRITICAL AREAS OF SLEEP STATIONS & WORK AREA COMMUNICATION
- UHF MAY REQUIRE DETERMINATION FOR PHYSICAL & PSYCHOLOGICAL EFFECTS
- SLEEP AREAS SHOULD NOT BE COMPLETELY SILENT
- ADEQUATE COMMUNICATIONS MAY REQUIRE LIGHTWEIGHT HEADSETS
- SCREEN CANDIDATES FOR LOW NOISE SENSITIVITY

APOLLO ACOUSTICS

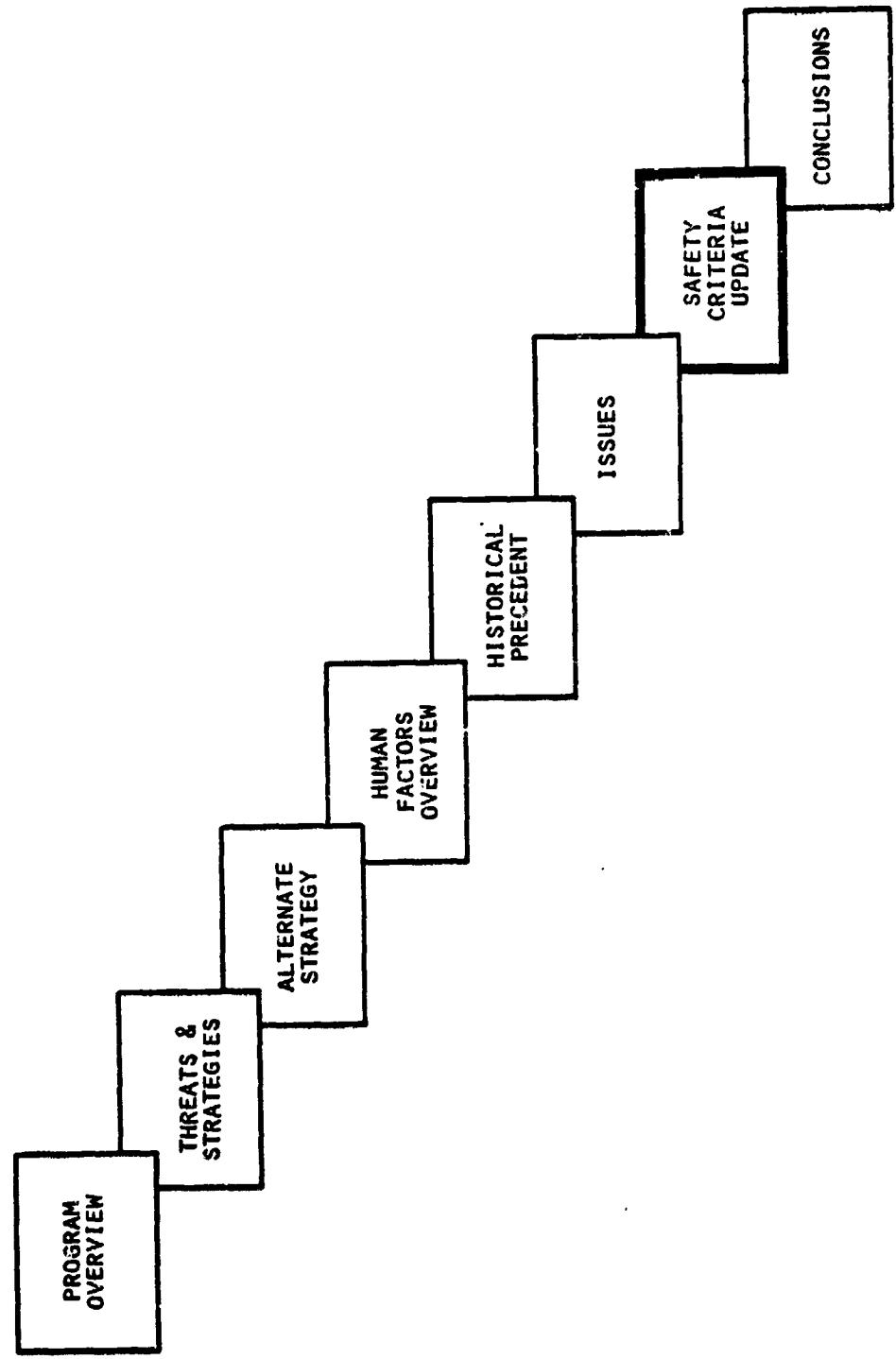


SHUTTLE ACOUSTICS

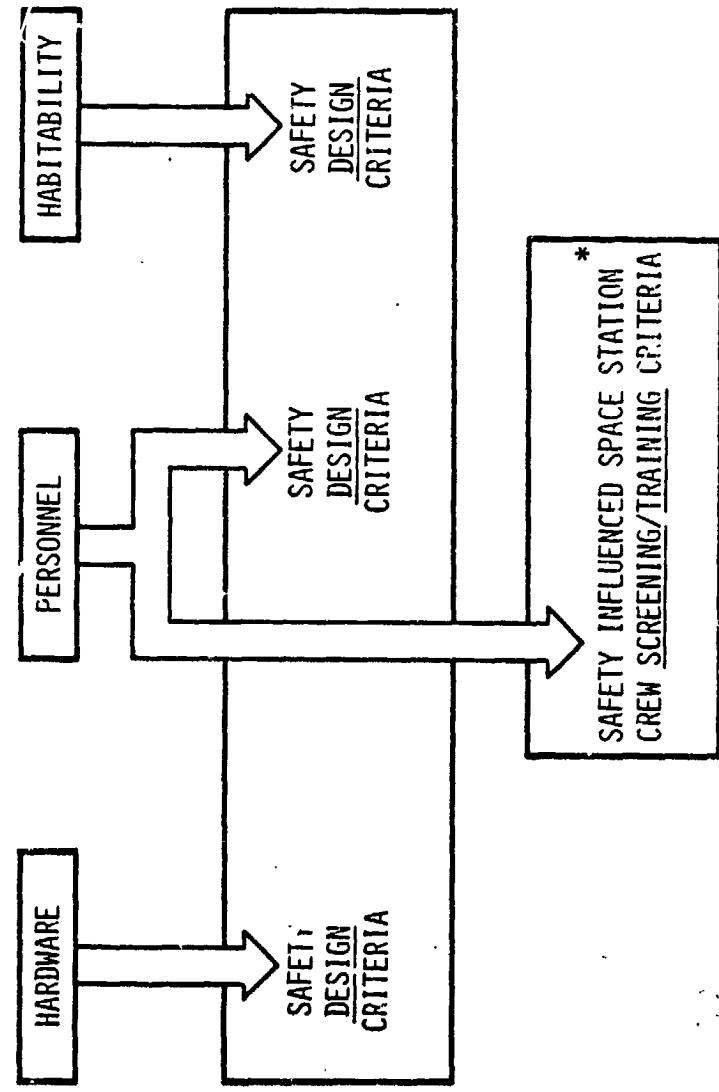


ON-ORBIT ACOUSTIC NOISE

- ALL ORBITAL VEHICLES HAVE EXPERIENCED SOME FORM OF ACOUSTIC NOISE PROBLEMS
- PREVIOUS VEHICLE NOISE PROBLEMS HAVE BEEN COMPLEX & USUALLY RESULTED IN "TRADE-OFFS" & COMPROMISES INVOLVING:
 - SPECIFICATION REQUIREMENTS RELAXATION
 - ADDED DEVELOPMENT COSTS
 - WEIGHT PENALTIES
 - SCHEDULE IMPACTS
- CONCLUSIONS/RECOMMENDATIONS
 - OPERATIONS SHOULD CONSIDER THE LIMITS NOTED IN CHARTS
 - ATTAIN A REASONABLY QUIET SPACE STATION
 - IMPOSE NECESSARY DESIGN REQUIREMENTS & SPECIFICATIONS DURING INITIAL PHASE OF PROGRAM FOR BOTH PRIMARY & SUBCONTRACTORS
 - INVESTIGATE & UTILIZE THE LATEST TECHNOLOGY IN ATTENUATION FOR ACOUSTIC DESIGN & MATERIALS



INITIAL HUMAN FACTORS ASSESSMENTS
SAFETY CRITERIA DEVELOPMENT



*HOW IS THIS INCORPORATED INTO SPACE STATION DEVELOPMENT

CREW SAFETY CRITERIA
SUMMARY

CATEGORIES RELATING TO:

- DAMAGE TOLERANCE 12
- CREW PROTECTION 27
- STATION INTEGRITY 11
- CONTINGENCY CONTROL 8

NEW CRITERIA

- STATION INTEGRITY 4
- SELECTION/INDOCTRINATION
(NEW HUMAN FACTORS CATEGORY) 5

TOTAL 67

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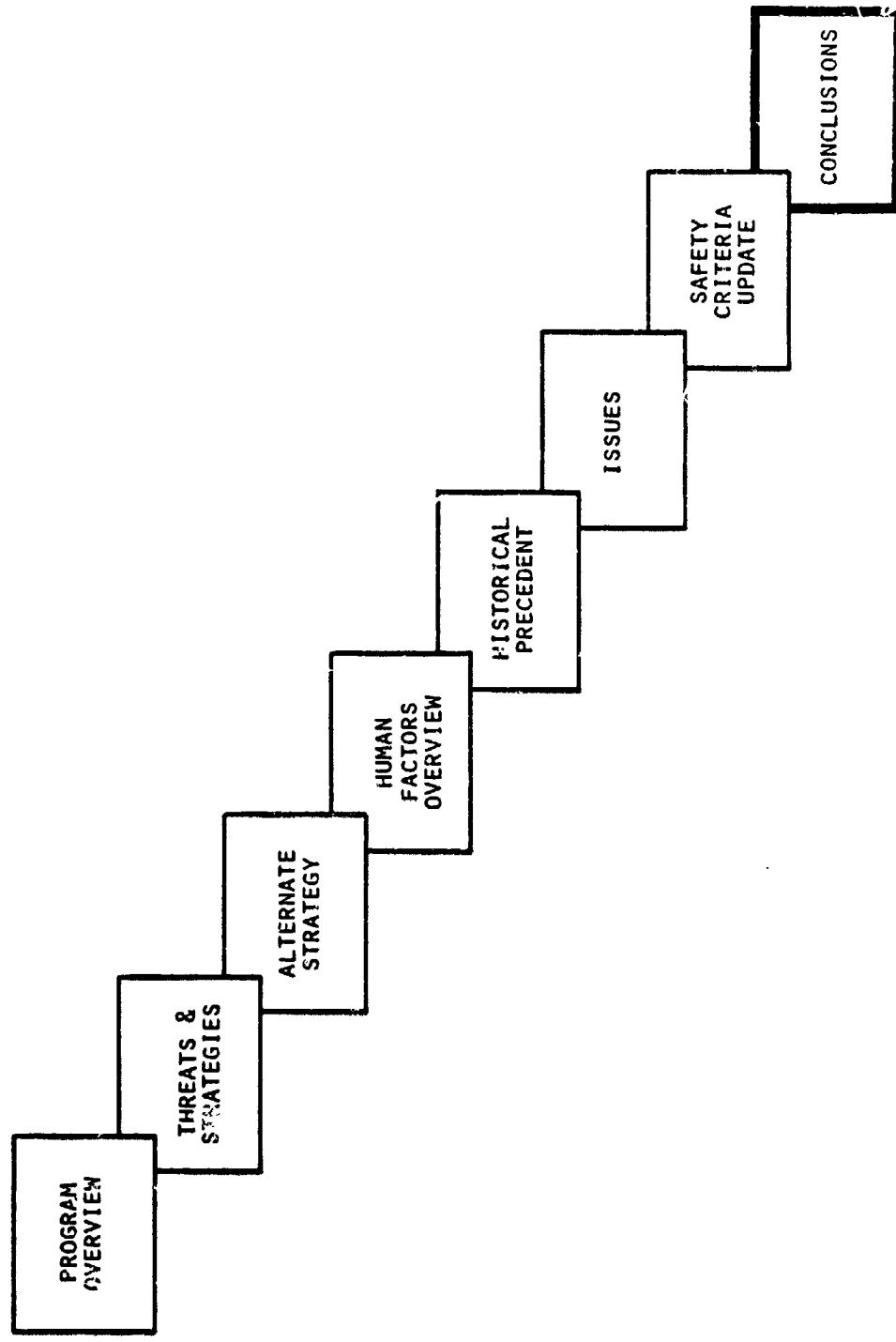
NEW CRITERIA

STATION INTEGRITY

- C-13 PROVISIONS SHALL BE MADE FOR INFLIGHT SERVICING, ADJUSTING, CLEANING, REMOVAL & REPLACEMENT OF OFFENDING COMPONENTS, & TESTING & REPAIRING OF ALL CRITICAL SUBSYSTEMS
- C-14 WEAR ITEMS SHOULD BE LIFE-CYCLE TESTED IN A REALISTIC ENVIRONMENT
- C-15 ALL PERSONNEL ITEMS SHOULD BE SCREENED FOR FLAMMABILITY & TOXICITY
- C-12 SPACE STATION MODULES SHOULD BE TUMBLED TO RID THEM OF INTERNAL DEBRIS & CONTAMINANTS IMMEDIATELY PRIOR TO PREPARATION FOR LAUNCH

NEW CATEGORY OF CRITERIA
SELECTION/INDOCTRINATION

- E-1 CREW SELECTION SHOULD BE BASED ON SELECTEES' CROSS-TRAINABILITY IN FIELDS OTHER THAN SPECIALTY
- E-2 ORBITAL CREW SHOULD BE AN INTEGRAL PART OF THE AIR/GROUND SYSTEM ACTIVE INTERFACE WITH ON-ORBIT CREWS
- E-3 STATION CREWS & TEAMING SHOULD ALLOW EQUAL THIRDS OF SCHEDULE FOR ON-ORBIT, GROUND INTERFACE OPERATIONS & RECYCLE OPERATIONS (POST-ORBIT REHABILITATION, LEAVE, ADDITIONAL TRAINING, PUBLIC RELATIONS, ETC.)
- E-4 ASSURANCE SHOULD BE PROVIDED THAT EACH MISSION SEGMENT CREW IS FAMILIAR WITH:
 - 1. STATION OPERATIONS & MAINTENANCE AS CONCERN'S CRITICAL SUBSYSTEMS, &
 - 2. PROCEDURES NECESSARY TO RENDER "SAFE" ALL EXPERIMENTS AND/OR USER PROCESSES
- E-5 SCREENING CRITERIA SHOULD INCLUDE ASSESSMENT OF ATTITUDES, PHYSICAL NEEDS, PSYCHOLOGICAL NEEDS, PERSONALITY TRAITS, ABILITY TO FUNCTION UNDER STRESS, ABILITY TO ACCEPT DIRECTION, & TBD



CONCLUSION - HUMAN FACTORS

- 48 AREAS OF IMPACT IDENTIFIED
- SAFETY CRITERIA THAT ARE NOT DESIGN CRITERIA MAY BE DIFFICULT TO INCORPORATE IN SPACE STATION PROGRAM
- TERRITORIAL ISSUES
- HUMAN FACTORS ISSUES THAT IMPACT MISSION OPERATIONS
- CREW SELECTION AND SUPPORT
- CREW TRAINING
- SPACE STATION HUMAN FACTORS AGGREGATES THE MOST SEVERE PERSONNEL STRESSORS OF ISOLATED, CONFINED ENVIRONMENTS, INCLUDING CURRENT SPACE ACTIVITIES
- EIGHT AREAS WILL BE REVIEWED IN THIS STUDY, BASED ON CONFIGURATION IMPACT IMPLICATIONS

TUESDAY

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